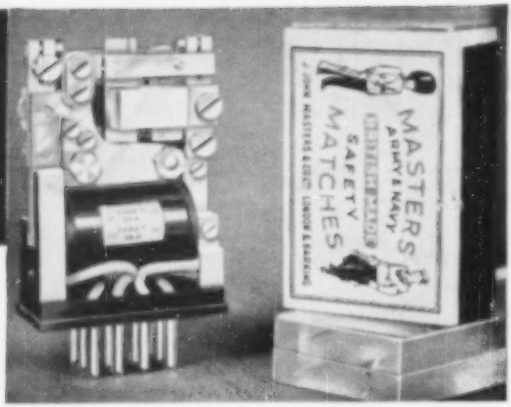
WIRELESS ENGINEER

THE JOURNAL OF RADIO RESEARCH & PROGRESS

DECEMBER 1950

VOL. XXVII No. 327 TWO SHILLINGS AND SIXPENCE

CARPENTER POLARIZED RELAY TYPE 5



MAGNETIC polepieces constitute main frame and carry all other components. Hence no space is wasted on a frame structure and great rigidity and high thermal stability is secured.

Axis of vibration of armature passes through centre of gravity, hence absence of positional error and virtual immunity from effect of vibration.

The only adjustment required is that of contact adjustment screws. No contact chatter.

Two generic types of the Relay are made, each of which may be had on either plug or solder tag base as follows :—

TYPE 5A Lightly side stable high sensitivity model, plug-in base, 12 pins. When adjusted to a static gap of ·002 ins. this model has the following characteristics :—

Side stability (in absence of signal current) 4 grammes. Minimum excitation 2·5 ampere turns R.M.S. at 50 c/s. Working excitation for robust operation 4 ampere turns* R.M.S. at 50 c/s.

Contact Pressure at 4 ampere turns R.M.S. 12 grammes. Maximum speed without bias disturbance or contact chatter, 60 c/s. At about 65 c/s. there is some bias, of the order of 5°, but above this the Relay works faultlessly up to about 120 c/s.

TYPE 5C As Type 5A but with soldering tags instead of plug-in base.

Complete details available on request.

TYPE 5B Centre stable model, plug-in base 12 pins. With total contact gap of ·002 ins. (i.e. ·001 in. on either side) this model has the following characteristics :—

Centre stability 3 grammes.
Minimum excitation 2·5 ampere turns D.C.
Minimum excitation 3·0 ampere turns R.M.S. at 50 c/s.
Working excitation for robust operation 4 ampere turns* R.M.S. at 50 c/s.

TYPE 5D As Type 5B but with soldering tags instead of plug-in base.

A number of standard windings is available up to a maximum of 19,000 turns. A maximum of four separate coils is possible.

Dimensions with cover but excluding wiring tags:

HEIGHT	2⅛"	56 mm.
WIDTH	1⅜"	37 mm.
DEPTH	¾"	19 mm.
WEIGHT	4.8 ozs.	137 gm.

**4 ampere turns corresponds to about 2mVa at 50 c/s. 0·12mW D.C.*

Manufactured by the Sole Licensees :

TELEPHONE MANUFACTURING COMPANY LIMITED

Contractors to British, Commonwealth and Foreign Governments

HOLLINGSWORTH WORKS · DULWICH · LONDON, S.E.21. *Telephone :* GIPsy Hill 2211 (10 *lines*)

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AND NOW A FEW WORDS ABOUT SERVICE

Our unique Monthly Service covers primarily the despatch of "THE GENERAL RADIO EXPERIMENTER," a monthly house organ published by "G.R." In this Journal is published all information concerning new "G.R." items, so that all readers are kept abreast of latest developments. In addition there often appear authoritative articles of great importance covering many aspects of the technique of laboratory measurements and production practice.

The "GENERAL RADIO EXPERIMENTER" service is entirely free, and there is no expressed or even implied obligation to make purchases. We do, however, request certain reasonable information from applicants for admission, these being: Surname, full Christian Names, full address, Degrees or Title (if any), name and address of employers (if not self employed), and, if possible, type of work or chief interests. Additions to our lists are entirely at our discretion.

All applications should be addressed to:

CLAUDE LYONS LTD.

ELECTRICAL AND RADIO LABORATORY APPARATUS, ETC.

180 Tottenham Court Road, London, W.1, and 76 Oldhall Street, Liverpool, 3, Lancs.

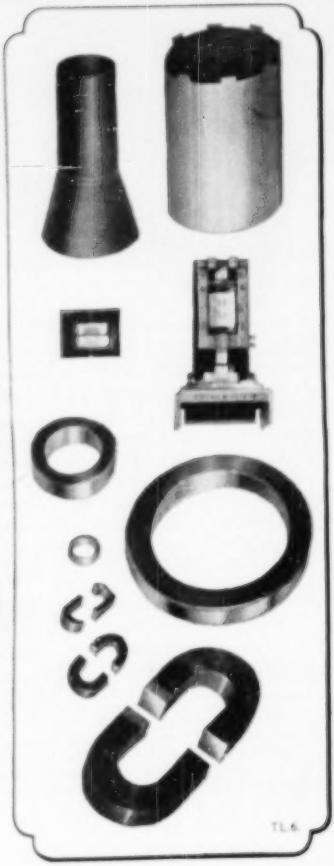
Standard MAGNETIC MATERIALS

PERMALLOY 'C'
for highest initial permeability. Useful for wide frequency band transformers, current transformers, chokes, relays and magnetic shielding.

PERMALLOY 'B'
for higher flux densities than Permalloy 'C' and high incremental permeability. Suitable for low power and intervalve transformers.

PERMALLOY 'D'
for very high resistivity without undue lowering of maximum flux density or of the Curie point. Small variation of permeability with frequency. Ideal for H.F. applications.

V—PERMENDUR
for high permeability with unusually high flux density. Specially applied to high quality diaphragms and pole pieces



Standard Magnetic Materials, which have been steadily improved and extended in range over many years, are produced by a Company which has the unique advantage of being also a large scale user of these materials.

Standard Telephones and Cables Limited

(Registered Office: Connaught House, Aldwych, London, W.C.2)
(Telephone Line Division)
NORTH WOOLWICH, LONDON, E.16. Telephone: Albert Dock 1401

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Modern in conception, design and performance, the E.2., with its exceptionally wide range, not only fulfills to-day's needs of radio and television, but anticipates the requirements of tomorrow. More than ordinary care has been used in screening and filtering. As a result, stray field is less than 3 microvolts at 100 Mc/s. ● *Frequency accuracy of ± 1% extends over the whole range.* ● *Output voltage 1 μV to 100 mV. and approx. 1v at full R.F. Socket.* ● *Internal modulation, external modulation to 80%* ● *A.F. Output variable 0-12v at 400 c/s.* ● *Size 13" x 10½" x 7½".* ● *Weight 15 lbs.*

LIST PRICE **£23 . 10 . 0**

Full details in Folder S14/V.

TYPE E2

100 Kc/s - 100 Mc/s ON FUNDAMENTALS

Advance
SIGNAL GENERATOR

ADVANCE COMPONENTS LTD. BACK ROAD, SHERNHALL STREET, LONDON, E.17.

'Phone: LARkswood 4346/7/8.

Ediswan Mazda Trigatron Pulse Modulators

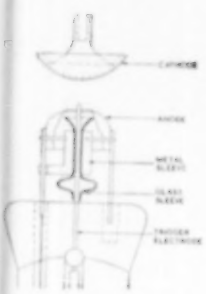
A Trigatron is a spark gap which operates as a switch for discharging a delay line in pulse series modulation. The instant of breakdown can be accurately controlled by means of a triggering voltage applied to a third electrode.

For medium and low powers the Trigatron is unrivalled, on account of its long life, low price and ability to operate under wide variations of ambient temperature. In addition the valve is of small overall dimensions.

The following valves comprise the Mazda range of Trigatrons :—

	24B1	24B2	24C3	24D4
Approx. Peak Pulse Power Output (kW)	150	150	530	250
Main Gap Hold-off Voltage (kV peak)	7.2	7.2	13.3	16
Line and Load Impedance (ohms)	80	80	80	250
Average Trigger Voltage (kV peak)	3.2	3.5	4.0	3.8

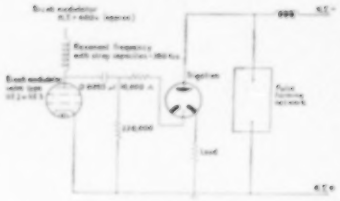
The 24B2 is a smaller version of the 24B1 with a consequent reduction in life.



Description of Operation

The Trigatron remains quiescent with hold-off voltage between cathode and anode, until the trigger voltage is applied. This distorts the field between anode and cathode converting the sphere to sphere gap into a point to sphere gap, with its consequent lower breakdown voltage. As the trigger voltage progressively rises a point is reached when the distortion of the field is sufficient to cause the trigger to cathode gap to break down. The potential of the trigger electrode then immediately drops from its positive potential, to the negative potential of the cathode, and consequently the trigger to anode gap breaks down. Once ionisation is established, the arc will continue for the remainder of the delay line discharge period.

The initiation of the discharge depends on the presence of a free electron near the cathode electrode ; hence the timing accuracy may be improved by ensuring a sufficiently copious supply of these electrons. This is arranged by irradiating the gap with ultra violet light produced by a corona discharge between the trigger electrode and the metal sleeve connected to the anode (see outline of electrode structure), resulting in the release of photo-electrons from the cathode.



Typical circuit using 24B1.

INFORMATION FOR DESIGNERS

This is the first of a series of occasional advertisements in which it is hoped to assist designers of Electronic Apparatus by bringing to their notice more detailed information regarding the characteristics of new or special types of Ediswan Mazda valves in the hope that it will be of interest and assistance in the design of new equipment.

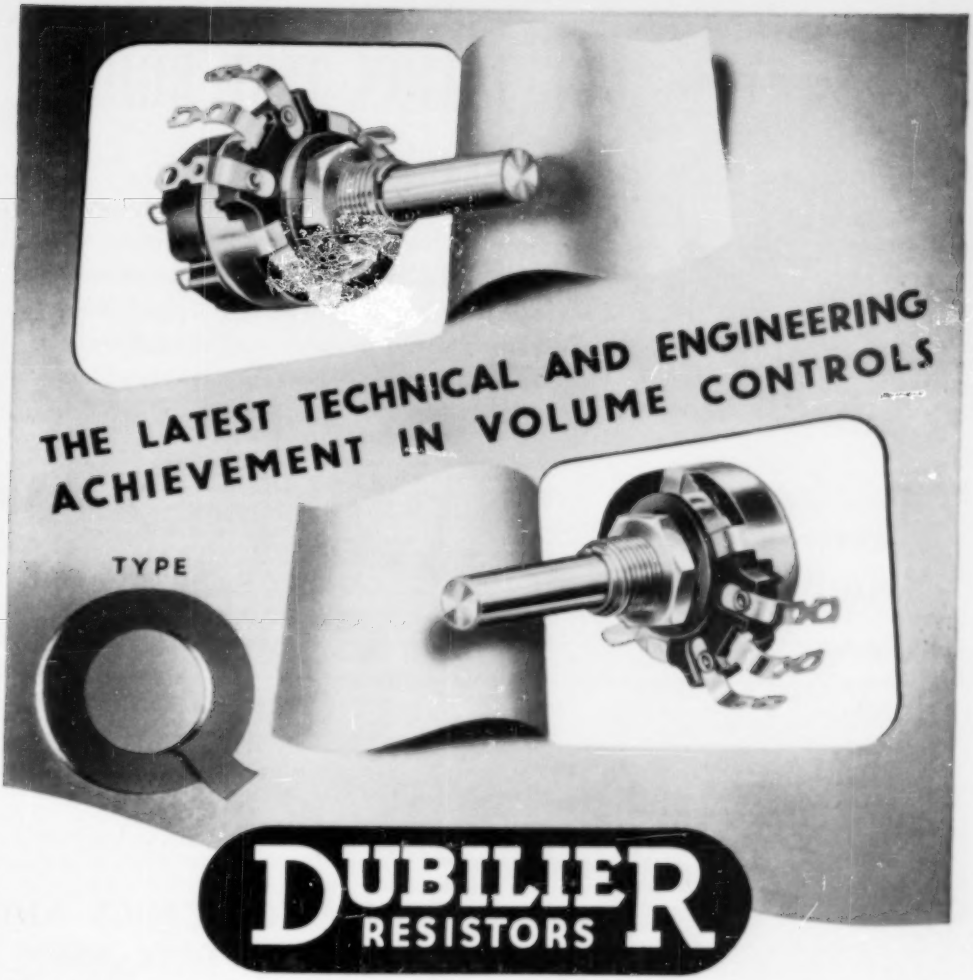
EDISWAN Mazda Radio Valves & Cathode Ray Tubes

THE EDISON SWAN ELECTRIC CO., LTD., Head Office, 155 CHARING CROSS RD., LONDON, W.C.2

Member of the A.E.I. Group of Companies.

Branches in all principal towns.

RV10



The new Dubilier Type Q Volume Control has all the essential outstanding features.

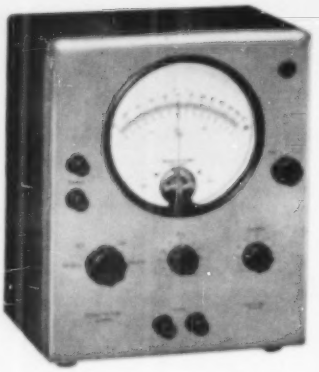
- Only $\frac{13}{16}$" diameter.
- Conservatively rated at $\frac{1}{4}$ watt.
- Specially processed moisture-proof element.
- Contactor, non-tarnishing bronze alloy dual spring of unique design.
- Noise level uniform and consistently low.
- Small physical size and light weight.
- Wear, average variation 5% after 25,000 rotations.
- Temperature Coefficient 0.02% per °C to 0.05% per °C.

Full details and samples are available to Radio Manufacturers upon application, but switch models of this volume control cannot be supplied for the time being.

DUBILIER CONDENSER CO. (1925) LTD., DUCON WORKS, VICTORIA ROAD, N. ACTON, LONDON, W.3

'Phone: Acorn 2241 (5 lines). 'Grams: Hivoltcon, Wesphone, London. Cables: Hivoltcon, London. Marconi International Code.

D61A.



DEVIATION TEST BRIDGE

Type 1502 and 1507

indicates on a large illuminated scale the percentage deviated from an arbitrary impedance. The bridge is particularly suitable for checking resistors, capacitors and inductors in industrial plants, but has also proved useful in many special measurements based on comparison between two impedances.

Specification :

Measuring Objects for Deviation Measurements: Resistance 10Ω—10 MΩ capacitance 50 pF— μF, inductance 2 mH —100 H for type 1502. Capacitance 25 pF —0.1 μF, inductance 100 μH—0.3 H, resistance 20Ω—100kΩ for type 1507.
Measuring Objects for Direct Reading with External Standards : Resistance ranges 0—0.7Ω to 0—3.3 MΩ, capacitance ranges 0—7 pF to 0—3.3 μF for type 1502 0—7 pF to 0—0.033 μF for type 1507.
Measuring Frequency : 1000 c/s for type 1502 and 50 kc/s for type 1507.
Instrument : Large moving-coil instrument permits easy readings. Illuminated scale with zero point in the centre. The instrument is safeguarded against overloads. Full scale deflection at 7% and 25%.
Comparison Accuracy : Better than 0.1% at zero point. The zero point is independent on the line voltage.
Tolerance Accuracy : Better than 5% at full scale deflection.
A.C. Hum: The bridge is not sensitive to hum voltages.
Power Supply : 115-127-150-220 volts a.c. Power consumption 40 watts.
Dimensions: 13 (height) × 11 (width) × 8 (depth excl. dials) inches.

Manufactured by

Brüel & Kjær

Nærum, Denmark

Another Murex contribution

TO THE ELECTRONICS AND ELECTRICAL INDUSTRIES

TANTALUM

We also supply Tungsten and Molybdenum metals and powders, and Tantalum powders, Titanium Hydride, Zirconium Hydride, and many other metallurgical products.

We are now making pure TANTALUM ROD, SHEET and WIRE—the first time these materials have been made in Great Britain.
We shall be pleased to have details of your requirements.

MUREX LTD · **(Powder Metallurgy Division)** · **Rainham** · **Essex** · *Telephone : Rainham, Essex, 240*
LONDON SALES OFFICE : CENTRAL HOUSE, UPPER WOBURN PLACE, W.C.1. Tel.: EUSton 8265.

Recipe for Reliability

Take 16 gms. of moulding powder; 1 gm. of S.R.B.P. sheet; 14 gms. of brass bar; 3 gms. of brass strip; 5 gms. of steel strip; 4 gms. of copper strip;

add Silver alloy, aluminium wire and steel wire as required.

— plus 50 years of experience,

and the result is—

THE WORLD'S FINEST SWITCH *for*

ELECTRONIC & RADIO APPLICATIONS

For more than 50 years the name Cutler-Hammer has stood for all that is best in switch design. Now C-H switches are being made in Britain in a wide range of 3, 6 and 10 amp. types operated by lever, plunger, slider or trigger mechanisms. To be sure of long dependable service for your product with complete freedom from all switch troubles, it is in your interests to standardise on Cutler-Hammer.

Other British N.S.F. Products include: 'OAK' Rotary, Push-button and Slider switches, Carbon and wire-wound potentiometers for Television and Radio applications.

NSF CUTLER-HAMMER APPLIANCE SWITCHES C-H

"THE SWITCH PEOPLE"

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Recognised as the Most Reliable Valveholders

Now in full production

NOVAL and B7G

Valveholders of all types in

NYLON LOADED BAKELITE

We make all types of Valveholders

THE McMURDO INSTRUMENT CO., LTD., VICTORIA WORKS ASHTEAD, SURREY · ASHTEAD 3401

Trade Secret?

It's no secret that the prime mover behind almost every automatic temperature-operated device is a Telcon bimetallic strip.

Telcon Thermostatic Bimetals are available in three different combinations to suit a wide range of conditions, either in strip form or as stamped or pressed components to manufacturers' drawings. Indispensable wherever there is a need for temperature change to exert a controlling or indicating function, their industrial applications are inexhaustible.

If you are contemplating a new product, we should be glad to co-operate; our technical staff is always at your service with sound advice based on long experience.

Our Representative will call, or full engineering data and samples will be sent on request.

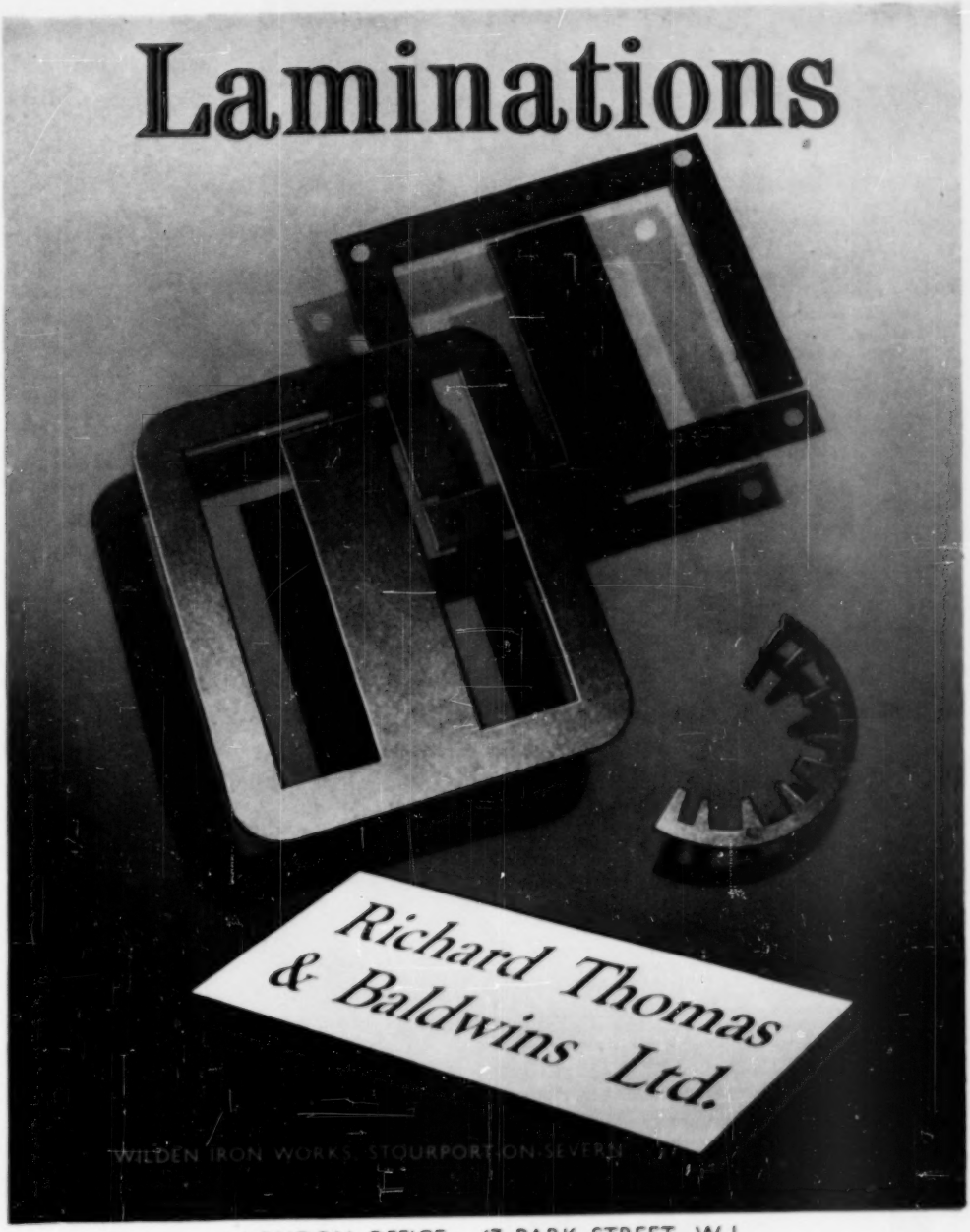
TELCON THERMOSTATIC BIMETALS

THE TELEGRAPH CONSTRUCTION & MAINTENANCE CO. LTD.

Head Office: 22, Old Broad Street, London, E.C.2. Telephone: LONdon Wall 7104

Enquiries to: Telcon Works, Greenwich, S.E.10. Telephone: GREenwich 3291

TELCON FOUNDED 1864



LONDON OFFICE : 47 PARK STREET, W.1.

Photograph by courtesy of Hollick and Taylor Recording Studio Birmingham.

From the comprehensive range of Painton faders, types are available to meet all the exacting requirements of modern recording technique. From B.B.C. studio to home recorder you cannot do better than rely upon . . . . .

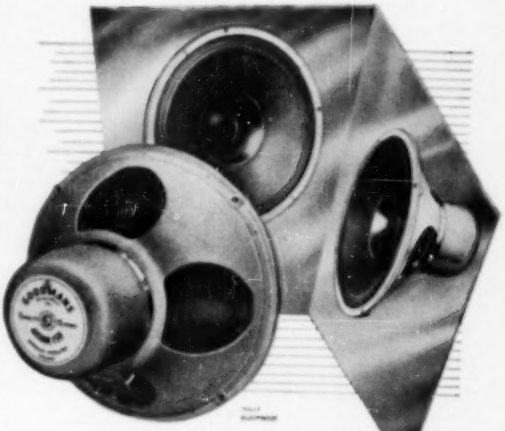
Control by **PAINTON**

PAINTON & CO LTD · KINGSTHORPE NORTHAMPTON

Presenting

GOODMANS

NEW HIGH FIDELITY—12" P.M. TWIN CONE **AXIOM 150**



This 12in. high fidelity unit has a twin-curvilinear diaphragm (patent No. 451754). A carefully designed magnet assembly using anisotropic material provides a total flux of 158,000 maxwells on a 1¼in. pole. The back centring device is a dustproof bakelised linen disc with concentric corrugations.

The combination of these features gives this precision-built instrument an outstandingly wide coverage from 40 to 15,000 c.p.s. free from bass modulation effects.

An ideal high fidelity reproducer for the record enthusiast and the connoisseur of wide range musical reproduction, it gives exceptionally fine transient and frequency response.

Frequency Coverage, 40–15,000 c.p.s.
Overall Diameter, 12¾ in. 31.3 cm.
Overall Depth, 6 15/16 in. 17.6 cm.
Fundamental Resonance, 55 c.p.s.
Voice Coil Diameter, 1¼in. 4.4 c.m.
Voice Coil Impedance 15 ohms at 400 c.p.s.
Maximum Power Capacity, 15 watts Peak A.C.
Flux Density, 14,000 gauss.
Nett Weight, 12 lb. 13 oz. (5,810 grammes).
Finish, Grey Rivelling Enamel.

£8 8s LIST

For use with this model we recommend Goodmans High Fidelity Heavy Duty Output Transformer Type H.4. Nett Weight 5 lb—2,265 grammes.

A Bass Reflex Cabinet measuring approximately 30in. x 23in. x 16in., and a corner cabinet have been specially designed for this loudspeaker and working drawings are available.

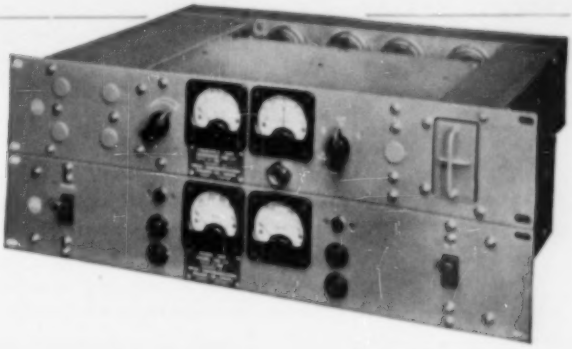
GOODMANS INDUSTRIES LIMITED
Lancelot Road, Wembley, Middx. *WEMbley 1200*

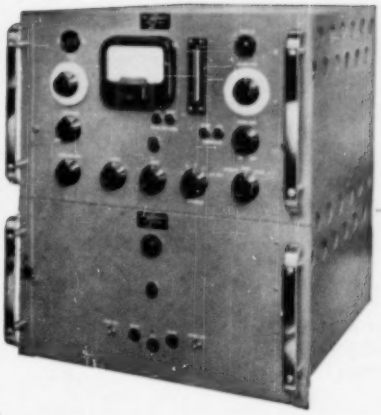
Frequency Shift Equipment...

Designed for conversion of any stable conventional communications receiver for frequency shift operation. Type FSR.1 is for single receiver working; other models are available for diversity reception.

TYPE FSR 1

for frequency shift reception





TYPE FSK 2

for frequency shift keying

These units can be fitted on site by station engineers, any modification of radio equipment necessitated being only of a minor nature.

RADIO & TRANSMISSION DIVISION

AUTOMATIC TELEPHONE & ELECTRIC CO. LTD.

Strowger House, Arundel Street, London, W.C.2.

Telephone: TEMple Bar 9262. Telegrams: Strowger, Estrand, London.

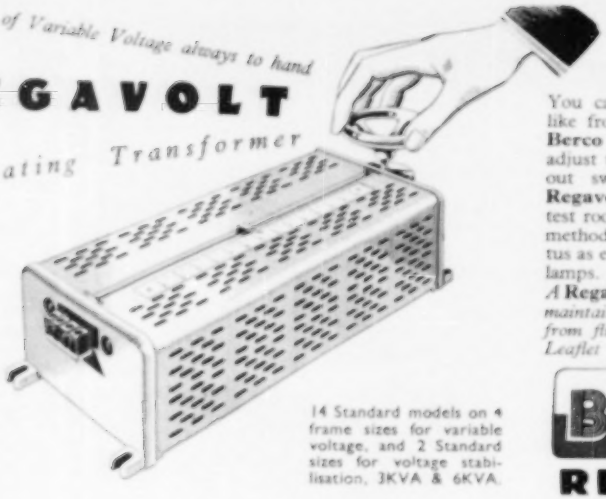
STROWGER WORKS, LIVERPOOL, 7.

A1403E-E24

A source of Variable Voltage always to hand

REGAVOLT

Regulating Transformer



14 Standard models on 4 frame sizes for variable voltage, and 2 Standard sizes for voltage stabilisation, 3KVA & 6KVA.

You can obtain any voltage you like from an A.C. supply with a **Berco Regavolt.** You can also adjust the voltage smoothly, without switching off the load. A **Regavolt** is indispensable in the test room and is the most efficient method of controlling such apparatus as electric furnaces, motors and lamps.

A **Regavolt** *is particularly useful for maintaining a constant supply voltage from fluctuating mains. Write for Leaflet* No. 605.

BERCO

REGAVOLT

Regulating Transformer

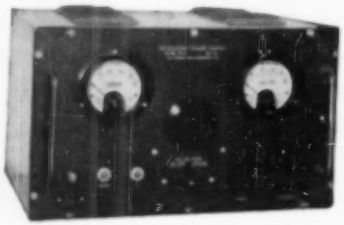
THE BRITISH ELECTRIC RESISTANCE CO. LTD.

Queensway, Ponders End, Middlesex · Telephone: Howard 1492 · Telegrams: Vitrohm, Enfield

BR3072-THI

ALL-POWER

CONSTANT VOLTAGE POWER SUPPLIES



SERIES 101.

MODEL 101-B.

Output: 200/350v. 0.250mA max.
Stability: Better than 0.1%.
Output Impedance: Less than 1 ohm.
Output Ripple: Less than 2mV. R.M.S.
Mains Supply: 200/250v. 45-60c/s.

Stabilization and regulation are maintained for all output currents from zero to 250mA and for mains voltage variation from + 10% to −15%.

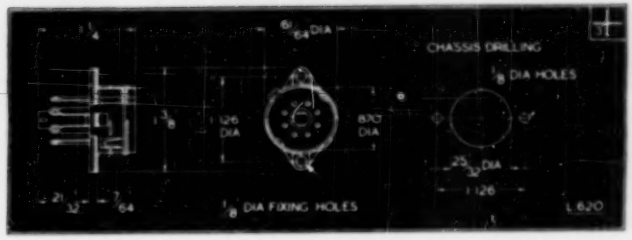
Details of further models on application.

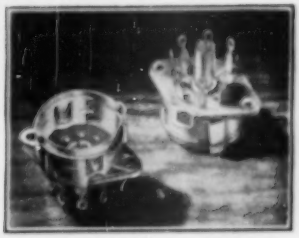
ALL-POWER TRANSFORMERS LTD.

CHERTSEY ROAD, BYFLEET, SURREY.

Tel: Byfleet 3224/5.

The "Belling-Lee" page for Engineers

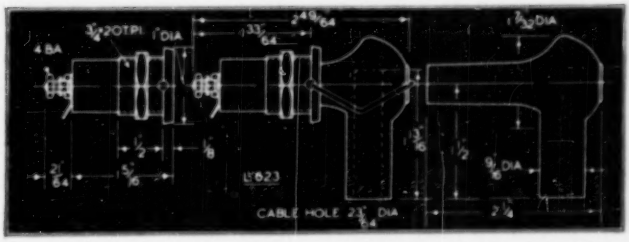


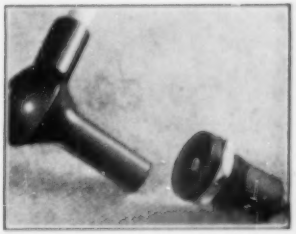


B8A Laminated
L.620

This valveholder is designed specifically for use with valves having a B8A base. It accepts all glass and metal base versions with or without spigot, and has silver plated phosphor bronze contacts (pen nib type, floating); spring retaining circlip over shroud; low contact resistance.

Contacts provide low shunt capacitance and handle peak to peak volts 1500 v, between each contact or between any contact and the spigot/shell connected together.





High Tension Plug and Socket
L.623/S Flex Socket
L.623/P Panel Plug

Suitable for television and other H.T. apparatus. Moulded in bakelite with adequate insulation provided, together with means for attaching a standard "cabtyre" connecting lead up to 9 mm.

The chassis section is one-hole fixing with anti-twist dowel, suitably nutted. With "O.Z." construction pin. Supplied with solder tag and eared washer for alternative methods of connection. Peak working 7000 volts.

A retainer for the flex part will be available shortly.

BELLING & LEE LTD
CAMBRIDGE ARTERIAL RD., ENFIELD, MIDDX., ENGLAND

The WESTON S.75 Multi-Range Test Set

53 Ranges with Rotary Switch Selection

This uniquely comprehensive Test Set has 53 ranges for measuring A.C. and D.C. current and voltage, resistance and insulation. It is completely self-contained, with internal batteries to provide power for the ohms ranges and self-contained power pack for insulation measurement at 500v. Selection is carried out by two 20-position switches. A fully-protective safety device is fitted and is operative for forward or reverse overload. The 150-division 6in. scale is uniformly divided and is fitted with an anti-parallax mirror. The set is enclosed in a handsome bakelite case and fully complies with B.S.S. No. 89 covering first-grade instruments. Full details of the ranges covered, and of the complete specification, will gladly be supplied on request.

SANGAMO WESTON LIMITED

ENFIELD, MIDDLESEX

TELEPHONE: ENFIELD 3434 (6 LINES) AND 1242 (4 LINES)
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WIRELESS ENGINEER

The Journal of Radio Research and Progress

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WIRELESS ENGINEER

Vol. XXVII DECEMBER 1950 No. 327

Michael Faraday and the Spinning Bar Magnet

PERHAPS we should apologize for raising again the meaningless but time-honoured question as to whether the field of a cylindrical bar magnet rotates with it when it is rotated about its axis, but we understand that experiments have been made within the last few months with the object of obtaining a definite answer to the question. We need hardly say that the supposed conclusions were entirely fallacious, but, as the experiments were based on some carried out by Faraday, we thought it desirable to look up and study carefully Faraday's descriptions of his experiments. They are given in Volume 1 of his "Researches in Electricity," paragraphs 217 to 230. After studying them carefully we can only admire the clarity of most of his descriptions and discussions, and say quite definitely that he is in no way to blame for the mental fog that seems to have enveloped the subject for many years, in spite of many efforts to dispel it.

The experiments are also described in Faraday's diary Vol. 1, pp. 402–404 and 413–414, and are dated December 1831.

It is interesting to note that the primary object of the experiments was to show that when current was produced by a wire cutting the magnetic curves, (that is, the lines of force) it was not necessary for it to "pass into positions of greater or less magnetic force," but that "always intersecting curves of equal magnetic intensity the mere motion was sufficient for the production of current."

"A copper disc was cemented upon the end of a magnet with paper intervening; the magnet and disc were rotated together and collectors attached to the galvanometer, brought into contact with the circumference and the central part of the copper plate. The galvanometer needle moved as in former cases, . . . Hence rotating the magnet causes no difference in the results, for a rotatory and a stationary magnet produce the same results upon the moving copper."

"A copper cylinder closed at one extremity was then put over the magnet, one half of which it enclosed like a cap; it was firmly fixed (to the magnet) and prevented from touching the magnet by interposed paper. The arrangement was then floated in a narrow jar of mercury, so that the lower edge of the copper cylinder touched the fluid metal; one wire of the galvanometer dipped into this mercury, and the other into a little cavity in the centre of the end of the copper cap." As in the case of the disc, the results were the same when the cylinder rotated, whether the magnet rotated or not.

Then follows an important conclusion. "That the metal of the magnet itself might be substituted for the moving cylinder, disc, or wire, seemed an inevitable consequence, and yet one which would exhibit the effects of magneto-electric induction in a striking form." A cylindrical magnet was floated pole upwards in a jar of mercury, the mercury reaching half way up the magnet. One wire dipped into the mercury, and the other into a drop of mercury in a little hole at the centre of the end. "The magnet was then revolved by a piece of string passed round it, and the galvanometer-needle immediately indicated a powerful current of electricity."

" Thus a *singular independence* of the magnetism and the bar in which it resides is rendered evident" (The italics are Faraday's).

This then would have been Faraday's answer to the meaningless question—Does the field revolve with the magnet? but seeing that the field was everywhere unchanging in strength and direction, it probably never occurred to him that anyone might imagine that the e.m.f. was induced in the stationary galvanometer leads, and he therefore never mentions their length or location.

In paragraph 224 he says that " experiments were then made for the purpose of ascertaining whether any return of the electric current could occur at the central or axial parts." This presumably meant circulation of current within the rotating magnet. He adds, " the belief being that it could not." In his diary this is worded somewhat differently: he says " The intention was to see whether, when the magnet was rotated, the parts at *ii* etc. could produce currents which the copper rod could discharge down the axis, it having the same angular velocity, as the other parts. It was expected not." A hole of $\frac{1}{4}$ inch diameter was drilled axially to near the middle of the magnet, and an insulated copper rod was passed down it to make contact with a little mercury at the bottom of the hole; the top projected $\frac{1}{4}$ inch beyond the magnet and carried a small cup of mercury for making contact. The top of the magnet also carried a pool of mercury but insulated from the rod. " The wires A and B from the galvanometer were dipped into these two portions of mercury; any current through them could, therefore, only pass down the magnet towards its equatorial parts and then up the copper rod; or vice versa." On rotating the magnet the galvanometer current was in the direction one would expect from the rotation of the magnet in the magnetic field, and the current was small, since the potential at the end of the magnet would not differ much from that of the axis. [Fig. 1(a)].

The magnet was then half immersed in a jar of mercury, the wire A remaining in contact with the top of the rod, while the wire B was removed from the end of the pole to the mercury bath, and therefore in close metallic communication with the equatorial parts of the magnet [Fig. 1(b)]. The current was, of course, much stronger. The wire A was then shifted from the rod to the polar mercury cup, so that the copper rod was out of the circuit [Fig. 1 (c)]. Faraday says, " The current was as strong as it was in the last trial and much stronger than at first." From these results he concludes, " Hence, it is evident that there is no discharge of the current at the centre of the magnet, for the current now freely evolved, is up through the magnet, but in the first experiment it was down. In fact, at that time [Fig. 1 (a)] it was only the part of the moving metal equal to a little disc extending from the end of the wire B in the mercury to the wire A that was efficient; i.e., moving with a different angular velocity to the rest of the circuit." He apparently saw that, apart from any drop due to its resistance, all parts of the central rod were at the same potential, and that the effective generator was the small disc at the pole end. This is emphasized by his conclusion in paragraph 230: " In the two after experiments, the *lateral* parts of the magnet or of the copper rod are those which move relative to the other parts of the circuit, i.e., the galvanometer wires; and being more extensive, intersecting more curves [lines of magnetic induction] or moving with more velocity, produce the greater effect. For the discal part, the direction of the induced electric current is the same in all, namely, from the circumference towards the centre." From this wording it appears that he was regarding the path from the B contact to the A contact as made up of two parts, namely, lateral (or longitudinal) and discal (or radial).

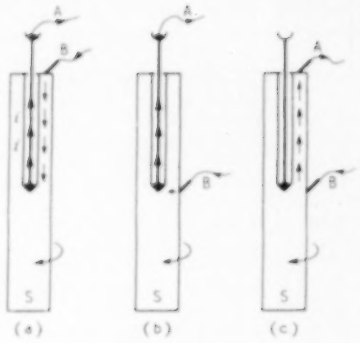

Fig. 1

We should point out that Fig. 1 is not a reproduction but a simplification of Faraday's illustrations.

Light is thrown on the working of his mind by the following interesting quotation from his Diary. " There is evidence of great power in these experiments, for the electricity had only 2, 3 or 4 inches of thick magnet to go through, and yet rather went through 27 or 30 feet of thin copper wire."

The action can, perhaps, be made clearer by considering Fig. 2. All points on the axis are obviously at the same potential, since on no theory does this cut any flux. The equatorial

disc cuts the whole flux of the magnet; as one approaches the poles the cross-sectional discs cut less and less flux, and the radial e.m.f. induced will vary somewhat as indicated by the curve with base PQ. If the axis is earthed, and the polarity and rotation are as shown, all the potentials and surfaces charges will be positive. Charges will be so distributed throughout the material that the resultant electric force within it is everywhere zero. There will be an electric field between all parts of the magnet surface and the negative charge induced on the earthed surroundings. If, however, the magnet is insulated from earth as it is brought up to speed, the axis and ends assume a negative potential. The potential curve of Fig. 2 retains its shape but, instead of the base PQ being at zero potential, a line such as MN must now represent zero potential, those parts of the curve to the right of it being positive and those to the left negative. Hence the equatorial parts of the surface are positively charged and the end parts negatively charged to an equal amount, so that the mean density of the surface charge is zero. If one were to earth a brush rubbing on the equator, the axis would become more negative still, and the whole surface would be charged negatively to various densities. The line SRT would then represent zero potential.

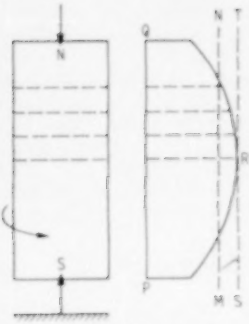

Fig. 2

The rotating bar magnet is a simple form of homopolar generator in which the axis is one terminal and the equator the other. In Fig. 1 we adopted the polarity and direction of rotation employed by Faraday, with which the axis is the positive terminal; in Fig. 2 the rotation is reversed so as to make the equator the positive terminal. The e.m.f. is the same along any path from the axis to the equator. The conditions would be exactly the same if the magnet were replaced by a similar brass cylinder rotating in a current-carrying solenoid producing an equivalent field. In each case a conducting cylinder is rotating in an unchanging magnetic field, and although the question of the rotation or non-rotation of the field has been cropping up for over a century it is surely meaningless.

G. W. O. H.

FERROMAGNETIC MATERIALS AND FERRITES*

Properties and Applications

By M. J. O. Strutt

(Electrotechnical Institute of the Swiss Federal Institute of Technology, Zurich)

Introduction

IN the applications of ferromagnetic materials to communication circuits the reduction of eddy-current losses is always important. These losses, at a given frequency, may be decreased by a reduction of linear dimensions and of the specific conductivity. This latter quantity however, lies within relatively narrow limits in metallic ferromagnetic materials and, as a result, the properties of non-metallic materials were considered as early as forty years ago. However, no really useful materials of this type (mostly iron oxides) have been produced until a few years ago and it is only quite recently that such materials have become available commercially. Thus, a brief consideration of the main points governing their properties and applications seems timely.

*Condensation of three lectures given by the author at London University on February 17th, 21st and 24th, 1949 by invitation.

MS accepted by the Editor, February 1950

Losses in Ferromagnetic Materials

In this discussion, rational units will be mainly used for the electromagnetic and other quantities: V, A, cm, sec. Magnetic field strength H is expressed in A/cm, one of these units being 1.257 oersted. Magnetic induction B is expressed in volt-sec/cm^2, one of these units being equal to 10^8 gauss. Magnetic permeability μ is equal to $\mu_0 \mu_r$, where $\mu_0 = 4\pi \cdot 10^{-9}$ henry/cm and $\mu_r = 1$ in the case of vacuum.

If we consider thin plates of magnetic material of thickness $2a$ of conductivity γ (mho/cm) placed in a homogeneous alternating magnetic field parallel to its surfaces, we obtain the following expression for the power loss (watts) in a volume V at an angular frequency ω:

$$P_w = \frac{\gamma}{24}\omega^2 4a^2 B^2_{max} V F(2\beta a). \quad .. \quad (1)$$

In this formula B_{max} is the mean value of the amplitude of magnetic induction over the cross-section of the plates under consideration and

$$\beta^2 = \frac{1}{2}\mu_a \mu_r \gamma\omega \quad .. \quad .. \quad .. \quad .. \quad (2)$$

μ_r being the effective relative permeability of the material at the given B_{max}. The function F

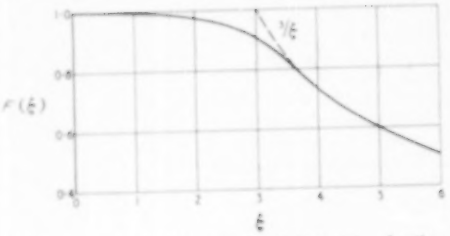

Fig. 1. Graph of function F of Equ. (1). In the figure the argument of F is denoted by $\xi = 2\beta a$.

of $2\beta a = \xi$ is shown in Fig. 1. It is seen that F is nearly unity for $\beta a \ll 1$ and is equal to $3/(2\beta a)$ for $\beta a \gg 1$. This implies that a reduction of eddy-current losses is obtained in every case by a reduction of linear dimensions (thickness a) and by a reduction of conductivity γ. These implications are also valid when different shapes of magnetic materials are placed in a homogeneous field: e.g., spheres, cylinders, ellipsoids, etc.

In the applications of ferromagnetic materials in communication circuits, the values of H and B are often so small that Lord Rayleigh's empirical results, obtained half a century ago, may be applied as to the relation between H and B. These results are summarized in Fig. 2, the corresponding expressions being:

if B is increased from $-B_1$ to B_1:

$$B = (\mu_a + \alpha H_1) H - \frac{\alpha}{2}(H_1^2 - H^2)$$

if B is decreased from B_1 to $-B_1$:

$$B = (\mu_a + \alpha H_1) H + \frac{\alpha}{2}(H_1^2 - H^2).$$

Here H_1 corresponds to B_1 and H to B.

We may now assume a cosine function for the dependence of H on time: $H = H_1 \cos \omega t$ and obtain by application of the above expressions, using Fourier's expansion:

$$B = (\mu_a + \alpha H_1) H_1 \cos \omega t + \frac{4}{\pi}\alpha H_1^2\left(\frac{\sin \omega t}{3} - \frac{\sin 3\omega t}{15} - \frac{\sin 5\omega t}{105} \ldots\right). \quad (3)$$

If a coil is properly arranged round the ferromagnetic core, a coefficient of self-inductance L arises at its terminals, expressed by:

$$L = L_0\left(1 + \frac{\alpha H_1}{\mu_a}\right), \quad .. \quad .. \quad .. \quad (4)$$

where L_0 is the value of L at very small values of H_1 such that the second term in brackets is insignificant compared with unity. The first term in brackets of Equ. (3) is a quarter period out of phase with the current in the coil. This obviously corresponds to an additional effective resistance R_h due to the hysteresis loop of Fig. 2:

$$\frac{R_h}{\omega L} = \frac{4}{3\pi}\frac{\alpha H_1}{\mu_a + \alpha H_1} = h_0 H_1 \approx \frac{4\alpha}{3\pi\mu_a} H_1 \quad .. \quad (5)$$

The approximation in the latter part of this equation is tolerable if $\alpha H_1 \ll \mu_a$. The symbol h_0 obviously has the dimension cm/A and is a measure of the loss by hysteresis.

We may express the eddy-current loss by a corresponding resistance R_e. If $\beta a \ll 1$ in Equ. (1), we obtain:

$$\frac{R_e}{\omega L} = \frac{1}{3}a^2\mu_0\mu_r\gamma\omega = \frac{\omega}{\omega_0}. \quad .. \quad .. \quad (6)$$

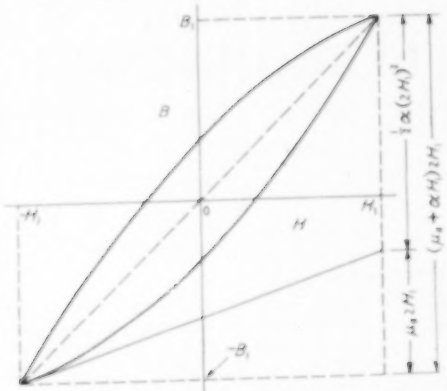

Fig. 2. Summary of Lord Rayleigh's empirical relations between magnetic induction B and magnetic-field strength H. The hysteresis loop is for H up to about 0.01 A/cm (taken from Ref. 1).

Here, obviously, ω_0 denotes an angular frequency fixed by the properties of the core:

$$\omega_0 = \frac{3}{a^2\mu_0\mu_r\gamma} \quad .. \quad .. \quad .. \quad .. \quad (7)$$

and the condition $\beta a \ll 1$ is equivalent to $\omega \ll \omega_0$.

This condition is satisfied if the individual parts of the core are of sufficiently small linear dimensions (e.g., thickness a).

Besides the losses by hysteresis and eddy currents, H. Jordan has shown by exact measurements in 1924 the existence of further losses, often indicated as 'residual losses'. These are in urgent need of further experimental and theoretical investigation. The equivalent resistance R_f of these losses may tentatively be expressed by:

$$\frac{R_f}{\omega L} = \epsilon \qquad (8)$$

where ϵ is little dependent on frequency up to, say, 10 kc/s with most materials.

The total equivalent resistance due to core losses is hence[1]:

$$\frac{R_t}{\omega L} = \frac{R_e + R_h + R_f}{\omega L} = \frac{\omega}{\omega_0} + h_0 H_1 + \epsilon \qquad (9)$$

Optimal Conditions for Cored Inductances

In many applications of these inductances the quality figure Q should attain a high value. As far as the core losses are concerned, the corresponding quality figure is given by the reciprocal value of the expression (9). A small volume of the inductance in question is obtained by a high value of μ_r. Hence, if high-quality inductances of small volume are desired, the expression $Q\mu_r$ should be considered and should be given as high a value as possible.

There is still another reason for the consideration of the product $Q\mu_r$. If, in a core of completely closed magnetic path, a non-magnetic gap is introduced, the effective value of μ_r decreases to μ_r'. On the other hand the effective value of Q increases to a value Q'. If the original value Q and μ_r satisfy the conditions $Q \gg 1$ and $\mu_r \gg 1$, we have $Q\mu_r = Q'\mu_r'$ as long as $\mu_r' \gg 1$. The introduction of a gap thus gives us a means of obtaining inductances of increased quality Q'.

According to Equ. (9) we may write:

$$\frac{1}{Q\mu_r} = \frac{\omega}{\mu_r \omega_0} + \frac{h_0}{\mu_r} H_1 + \frac{\epsilon}{\mu_r} \qquad (10)$$

From Equ. (7) we infer that the first term on the right of Equ. (10) is approximately independent of μ_r. As to the second term, the following reasoning may be applied. The value of H_1 is proportional to NI, where N is the number of turns of the inductance in question and I is the effective value of the a.c. through the coil. Furthermore, the coefficient L of self-inductance is proportional to $\mu_r N^2$ and hence H_1 becomes proportional to $I\sqrt{L/\mu_r}$. In many applications of inductances in communication circuits I and L have fixed values. Then obviously, the second term of Equ. (10) becomes proportional to:

$$\frac{R_h}{\mu_r \omega L} \approx \frac{h_0}{\mu_r \sqrt{\mu_r}} \qquad (11)$$

Summarizing, we see that the first term on the right of Equ. (10) is independent of μ_r while the second and the third terms both decrease if μ_r is increased. By using materials of higher μ_r we would hence expect the product $Q\mu_r$ to increase if h_0 and ω do not also increase too much and this increase of $Q\mu_r$ would in itself be desirable in many cases.

However, there is still the distortion caused by hysteresis. This may be inferred from Equ. (3). Considering, in particular, the third harmonic of the alternating voltage at the coil's terminals (due to the core), we obtain for the ratio of the effective third harmonic to fundamental voltage:

$$\frac{V_3}{V_1} = \frac{3}{5} \frac{4\pi H_1}{3\pi(\mu_a + \pi H_1)} = \frac{3}{5} \frac{R_h}{\omega L} \qquad (12)$$

By the application of Equ. (11) it is seen that V_3/V_1 is proportional to $h_0/\sqrt{\mu_r}$. In the known cases of materials with increased values of μ_r, the quantity h_0 also increases and the latter increase is faster than that of $\sqrt{\mu_r}$. Hence, an increase of μ_r would lead to increased distortion. We must conclude that the useful increase of

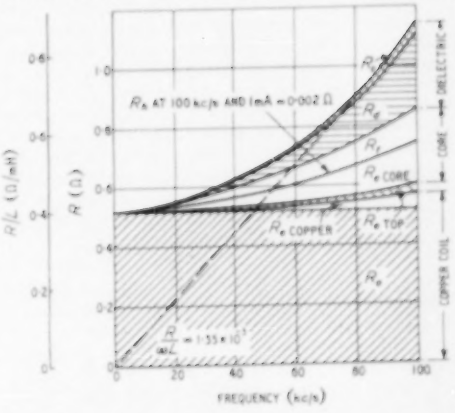

Fig. 3. *Characteristics of inductance with core of carbonyl iron powder embedded in a dielectric binder. The constituent parts of R are: d.c. resistance of coil R_0, additional eddy-current resistance of coil winding R_e, resistance R_{eTOP} equivalent to eddy-current losses in top and bottom of screening can, R_e equivalent to eddy-current losses of the core, R_h equivalent to hysteresis losses of the core (almost negligible), R_f equivalent to residual losses of the core, R_d equivalent to dielectric losses of insulation, R_c equivalent to dielectric losses of the core (Ref. 4).*

μ_r in magnetic materials is strictly limited by the ensuing distortion in communication circuits.

If the effective value of μ_r is decreased by the application of non-magnetic gaps in the magnetic circuit, the value of h_0 is decreased to h_0' and we have approximately:

$$\frac{h_0'/\sqrt{\mu_r'}}{h_0/\sqrt{\mu_r}} = \left(\frac{\mu_r'}{\mu_r}\right)^{3/2} \quad \ldots \quad \ldots \quad \ldots \quad (13)$$

Hence, the distortion V_3/V_1 is notably decreased by this procedure. At the same time Q is increased and the overall volume of the inductance is also increased.

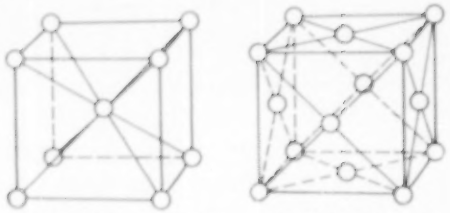

Fig. 4. *Pictures of cubic lattices, body-centred on the left and face-centred on the right.*

Before useful ferrite materials were available the requirements of communication circuits were covered by ferromagnetic materials of two types: granulated iron powders embedded in some suitable dielectric and sheets of suitable alloys[1, 3, 4]. As an example of the first type, the characteristics of an inductance with a ferromagnetic core are summarized in Fig. 3. It is seen that in this case, in which carbonyl iron granules of about 5 microns diameter embedded in a solid dielectric were used as a core, the contribution of hysteresis (R_h) to the overall losses is negligible. The carbonyl iron itself has a permeability μ_r of about 250 but as used in this core, the effective permeability μ_r' is about 15. The optimal value of $1/Q$ occurs at about 80 kc/s and amounts to 1.3×10^{-3}. The value of $h_0'/\sqrt{\mu_r'}$ for this inductance is slightly below 0.05, which complies with international agreements on this figure in communication circuits. Besides this iron-powder material, several types of sheet materials, alloys such as iron-nickel-copper (isoperm), were developed before the war. These could also meet the requirements as to $h_0/\sqrt{\mu_r}$ and Q, and below about 5 kc/s even surpassed the powder cores. Above 5 kc/s, however, powder cores are superior notably due to their smaller eddy losses[1, 2, 4, 5].

Physics of Ferromagnetism

In order to deal with the recent developments of ferrites for inductance cores, a few fundamental ideas about the present theory of ferromagnetism must be reviewed. We shall assume that the ions in a ferromagnetic material constitute a cubic lattice, which may be body centered or face centered (Fig. 4). The electrons, which are more or less mobile in this lattice, behave as tiny magnets owing to their mechanical spin. The ratio of the magnetic moment to the mechanical momentum of any top is, according to P. Blackett, a constant, called gyromagnetic ratio g. There is interaction between the spinning electrons and the ionic lattice, leading to an interaction energy E_i (joule/cm^3). This interaction gives rise to certain domains, named after P. Weiss, in which the magnetization has a preferred direction[1, 9]. The energy, required to turn one cm^3 of the substance in such a domain from the direction of minimum to that of maximum energy is called the 'anisotropy energy' E_a (joule/cm^3). The value of E_a is depicted in Fig. 5 for a cubic crystal, the edges of which are parallel to x, y and z. The directions of minimum E_a are parallel to the edges of the crystal. If a stress anisotropy exists, the values of E_a are altered, as shown in Fig. 5. The minimum stress σ occurring in any

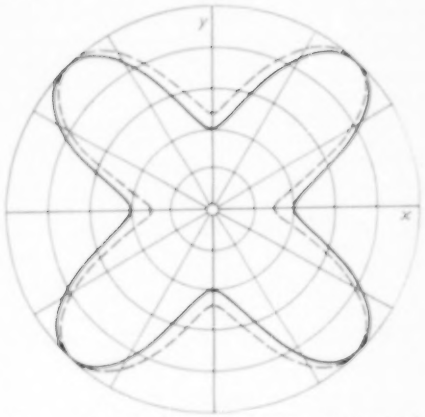

Fig. 5. *Value of anisotropy energy in a cubic crystal, the edges of which are parallel to x, y, z. The representation makes use of a polar diagram. The full curve corresponds to the case without stress, the broken curve to the case of a relatively small superimposed stress (taken from Ref. 1).*

material is such that the specific extension is of the order of magnitude of the magnetostriction value λ. Hence $\sigma_{min} \approx \lambda E$, where E is Young's modulus. For iron this yields $\sigma_{min} \approx 100$ kg/cm^2.

From this we see that E_a may, in general, be attributed to two different causes, the crystal

anisotropy energy E_ε (joule/cm^3) and the stress anisotropy energy $\sigma\lambda$ (joule/cm^3). In a given material, preponderance of E_ε as well as of $\sigma\lambda$ may occur[1].

Ferromagnetic theory, though still rudimentary, indicates that the initial permeability μ_r is high, if E_ε and $\sigma\lambda$ are small. Furthermore, the relative width of the hysteresis loop of Fig. 2 is small, if E_ε and $\sigma\lambda$ are small. Thus, we must search for materials in which E_ε and $\sigma\lambda$ are small simultaneously[1].

Some binary and ternary alloys are known, in which these conditions prevail at room temperature[7] (e.g., Sendust).

Composition of Useful Ferrites

It has been known for a very long time that the natural cubic ferrous ferrite $FeOFe_2O_3$ (magnetite) has ferromagnetic properties. Its behaviour as to maximum magnetization, anisotropy energy E_α, magnetostriction and permeability is comparable to that of nickel. Other ferrites may be obtained by substituting another bivalent metal of approximately equal ionic volume for the iron in the FeO component of the above material, the structure of which is of spinell type. Thus we obtain the following examples of cubic ferrites: $MgOFe_2O_3$, $NiOFe_2O_3$, $CoOFe_2O_3$, $ZnOFe_2O_3$. The last substance is nonmagnetic at room temperature, the others are ferromagnetic[7].

At the Curie temperature a ferromagnetic substance becomes nonmagnetic and remains so at higher temperatures. The above property of zinc ferrite points to its Curie temperature being below room temperature, while the Curie temperatures of the other ferrites are higher. By suitably mixing zinc ferrite with other ferrites we may obtain Curie temperatures between room temperature and the Curie temperatures of the other ferrites. The crystal anisotropy energy E_ε becomes very small if the Curie temperature is approached, long before the substance becomes nonmagnetic. The value of λ, however, remains different from zero almost up to the Curie temperature. Hence we may conclude that E_ε may be made sufficiently small at room temperature by the choice of a Curie temperature (obtained by a suitable mixture as observed above) not too far above room temperature. We must, however, apply a different procedure to decrease λ at room temperature. Now experimental evidence points to λ being of negative sign for all single ferrites (see the above examples) except $FeOFe_2O_3$, in which λ is of positive sign at room temperature. By the formation of suitable mixed crystals of the latter ferrite with any of the former, very small values of λ may be obtained at room temperature. Combining this evidence with the above on the addition of zinc ferrite it is seen that low values of E_ε as well as of λ simultaneously may be obtained at room temperature by a suitable choice of ferrite components. The application of this basic idea has led to useful ferrites, having high initial permeability as well as low hysteresis losses[7]. Although the application of ferrites was patented more than 40 years ago with a view to a decrease of the eddy-current losses in cores owing to the low conductivity of these materials, their low permeability and high hysteresis losses prevented them from being really useful up to quite recently. Due to the above basic ideas, however, these difficulties in the application of ferrites have now been overcome.

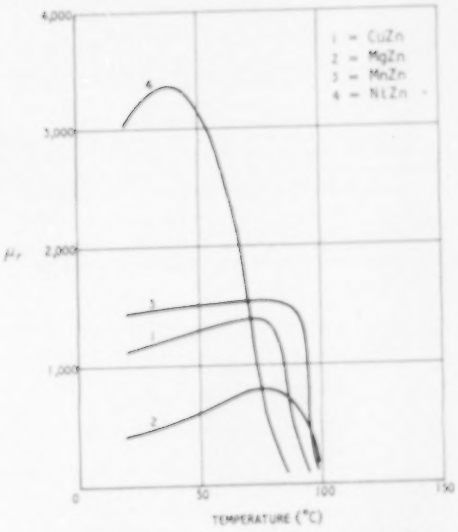

Fig. 6. *Dependence of initial relative permeability μ_r of ferrites types* 1 *to* 4 *(see Table* 1*) on temperature (taken from Ref.* 7*).*

It is obvious that a very careful selection of components and preparation of the products are required in order to achieve the indicated aims[7]. A cubic structure of the final ferrite is conducive to avoidance of stresses arising during the cooling down after sintering the components at temperatures of about 1200°C. This is due to the equal shrinking of cubic crystals in all directions. Polycrystalline aggregates of non-cubic structure tend to develop internal stresses upon cooling on account of anisotropy of shrinking. Such stresses may cause low permeability and high hysteresis losses.

In the preparation of the ferrites the proper oxides are pulverized and mixed thoroughly in the desired proportions. Thereupon a binder is added and the resulting plastic material is moulded; e.g., to rods and tubes. Another procedure is to put the dry powder into matrices and apply moulding under high pressure. Then a sintering process is applied to the moulded mass. The heating and cooling must be carried out in carefully determined cycles using special electric furnaces. In order to avoid chemical reactions of the sintering mass with the surrounding atmosphere, a special nitrogen atmosphere is in some cases provided during the sintering process. The sintered products, similar to certain ceramic materials, are of considerable hardness and may only be ground if further treatment is required. The linear tolerances of the sintered products are about 2 per cent. If smaller values are necessary, grinding must be applied[7].

Four examples of useful ferrites are given in Table 1 together with some pertinent data. Each product is a mixture of two ferrites; e.g., the first one of $CuOFe_2O_3$ and $ZnOFe_2O_3$, the proportion of Cu to Zn to Fe_2O_3 molecules being 20 : 30 : 50; i.e., exactly equimolecular. This latter feature is also true for the three other examples[7].

The long term stability of the ferrites is important for some applications. During the first months after production the initial permeability μ_r decreases a little, usually about 1 or 2 per cent. Upon magnetization in a strong field the variation of μ_r is of the same order of magnitude. The value of μ_r is dependent on temperature, as shown in Fig. 6. Between 10°C and 40°C its variation is in some cases about 0.2 per cent per degree. By the application of non-magnetic gaps the effective variations may of course be made smaller than the above figures.

Application of Ferrites

The eddy-current losses in ferrites, owing to their relatively low conductivity, are almost negligible in most practical applications up to about 100 kc/s. This may be seen from Equ. (1). In iron the conductivity γ is of the order of magnitude 10^5 mho/cm, while the highest value with the above ferrites is 0.02. Thus the losses, at equal values of a, ω, F and B_{max} would be about 10^7 times smaller with the ferrites. Conversely, for equal losses ferrite cores may be at least some thousand times thicker than comparable iron ones at the same frequency and the ratio holds for the frequency if the cores are the same thickness. Hysteresis losses in

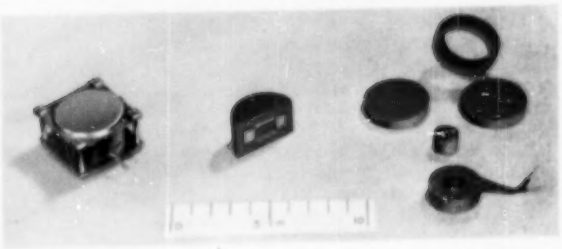

Fig. 7 (below). *Three comparable inductances containing cores of sheet alloy, of iron powder embedded in a a dielectric and of ferrite (on the right). The inductances being equal, the quality Q of the two coils on the left is about 220 at 60 kc/s, whereas the quality Q of the ferrite coil on the right at this frequency is 550.*

Fig. 8 (right). *Construction of ferrite-cored inductance of Fig. 7, the coil being wholly enclosed by ferrite material.*

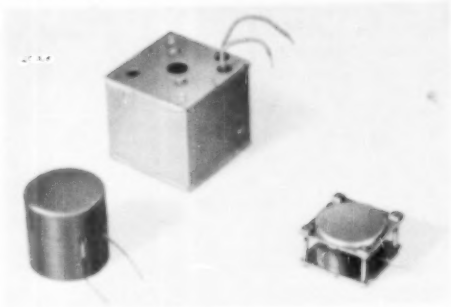

TABLE I

Type	Proportion	Curie Temp. (°C)	Conductivity at 20° (mho/cm)	Optimal μ_r obtained
1	$Cu/Zn/Fe_2O_3$ = 20/30/50	90	5×10^{-5}	1500
2	$Mg/Zn/Fe_2O_3$ = 25/25/50	100	2×10^{-6}	700
3	$Mn/Zn/Fe_2O_3$ = 25/25/50	100	2×10^{-2}	2000
4	$Ni/Zn/Fe_2O_3$ = 15/35/50	75	2×10^{-4}	4000

ferrites are also relatively small. The figure to be considered in most communication circuits is $h_0/\sqrt{\mu_r}$. This is given in Table 2 for some materials[7]. From this Table it is seen that the alloy called isoperm (about 50 per cent iron, 40 per cent nickel and 10 per cent copper) is superior as to relative distortion in communication circuits. Second is the ferrite type 3. Now the alloy must be applied in sheets in order to avoid eddy losses and hence is less suitable

TABLE 2

Material	μ_r	$h_0/\sqrt{\mu_r}$
Isoperm	85	3×10^{-4}
Permalloy	9000	3×10^{-2}
Sendust	55000	6×10^{-2}
Carbonyl iron	250	3×10^{-2}
Ferrite type 3	1000	8×10^{-4}

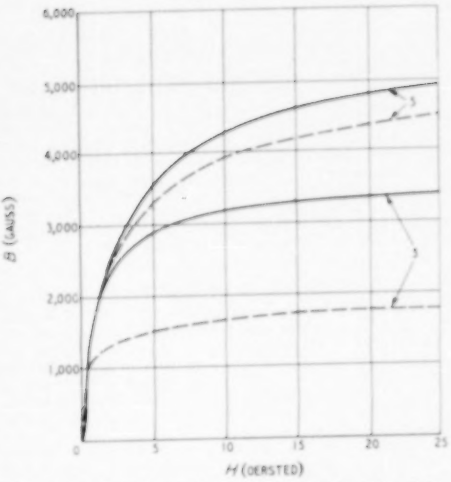

Fig. 9. *Magnetic induction as dependent on magnetic-field strength. The curves are for two types of ferrites, one of which is type 3 of Table 1. The solid line curves are for a temperature of 20° C and the dash-line is for 80°C.*

above, say, 5 kc/s. From this frequency onwards the ferrite material is preferable. By inserting gaps, the above values of μ_r and of $h_0/\sqrt{\mu_r}$ may be reduced according to Equ. (13).

Because of their high initial permeability μ_r some ferrites provide very effective screening of magnetic fields inside suitably-shaped cored inductances from the external space. The usual screening cans are hence far less affected by the internal alternating fields and thus the eddy-current losses in the can may be effectively reduced. The can dimensions may also be reduced and hence the overall dimensions of the inductances may be decreased. An example of a ferrite-cored inductance is shown in Fig. 7 compared with two other types, all being

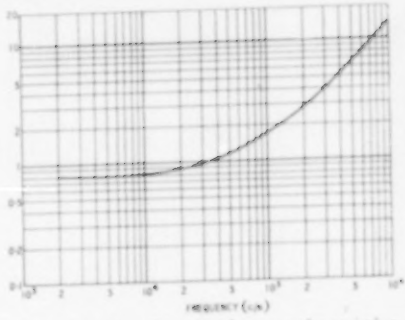

Fig. 10. *Plot of 100/Q against frequency for an inductance with a core of ferrite type 3 of Table 1 (taken from Ref. 8).*

suitable for use at 60 kc/s. The right-hand one has a core of ferrite type 3 and is smaller than the other two. The overall value of Q at 60 kc/s is about 600. The coil is entirely embedded in ferrite as shown in Fig. 8 in which the core construction, including two gaps, is seen.

The B–H curves of two ferrites, H being in oersted and B in gauss, are shown in Fig. 9 at the temperatures 20° and 80°C. It is particularly notable that the saturation value of magnetic induction is relatively low with these materials, as compared with sheet materials used in transformers. Owing to these low saturation values the application of ferrites in power-transformers is less desirable, for they would become too bulky.

As eddy-current losses and hysteresis losses are small in suitable ferrite cores, the residual losses corresponding to the third term on the right of Equ. (9) are of particular interest. These losses, together with the eddy-current losses, limit the applications of ferrite cores at high frequencies. This is shown in Fig. 10, picturing the reciprocal quality-figure $1/Q$ as dependent on frequency for a ferrite-cored inductance[8]. It may be shown theoretically that the sharp rise of $1/Q$ is due mainly to a rapid increase of the residual losses at a specific higher frequency which is characteristic to the material in question. The specific frequency at which the sharp rise of residual losses occurs is approximately inversely proportional to the initial

permeability μ_r of the ferrite material in the core. Hence, materials of lower μ_r may in general be used up to higher frequencies. Furthermore the rise is sharper if the material is of more homogeneous structure. The former fact is illustrated by a comparison of Figs. 10

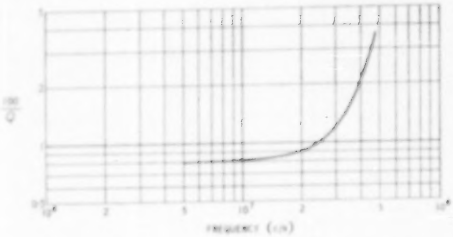

Fig. 11. Plot of 100/Q against frequency for a core of ferrite type 4 of Table 1. The ratio of initial permeabilities of ferrites types 1 to 4 is about 1000/50 for the ferrites used in the experiments (taken from Ref. 8).

and 11, as the initial permeabilities of the ferrites used in Fig. 10 and Fig. 11 are about 1 000 and 50 respectively[7, 8].

By their low losses at not too high frequencies ferrite cores are suitable for the construction of transformers if bulk does not constitute a particular consideration. Such almost loss-free transformers, if suitably wound, may offer better approximations to 'ideal' transformers than were hitherto obtainable using other core materials at moderately high frequencies.

Finally, the application of ferrite cores in magnetic amplifiers will be considered briefly. In cores of such amplifiers low losses are essential in view of the auxiliary oscillating flux which is required. In the case of d.c. amplifiers it is useful to apply a relatively high auxiliary frequency in order to reduce the time constant. In the case of a.c. amplifiers this requirement is even more stringent and the metallic ferromagnetic materials are in most cases unsuitable for the construction of such magnetic amplifiers. Here ferrite cores may fill the gap and thus make the construction of efficient a.c. magnetic amplifiers possible[6].

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UNIVERSAL DECIMAL CLASSIFICATION

The Fédération Internationale de Documentation is introducing a new service to U.D.C. users. This is the production of a half-yearly cumulative list of Proposed Extension notes to be known as Extensions. The first will contain all P.E. notes published and approved during the first half of 1950. The annual subscription is £2 10s. and orders may be placed with the Sales Department of British Standards Institution, 24/28, Victoria Street, Westminster, London, S.W.1.

F.B.I. REGISTER

The 1950/51 edition of the F.B.I. Register of British Manufacturers is the only authorized directory of the Federation of British Industries. Over 6,000 firms are included in its 832 pages together with addresses, trade marks, brands and trade names. The book is compiled and classified for quick reference with major instructions and cross-references in English, French and Spanish.

Priced at 42s., the book is obtainable from Kelly's Directories, 186, Strand, London, W.C.2 (home) and Iliffe & Sons, Ltd., Dorset House, Stamford Street, London, S.E.1 (overseas).

On account of the recent dispute in the printing trade, the publication of *Wireless Engineer* is still somewhat delayed. This issue, which is dated December, has been expanded to include double the normal number of Abstracts and Reference pages; it includes abstracts which would have normally appeared in the November and December issues.

PULSE GENERATOR OF FIXED REPETITION RATE

With Sine-wave Control

By F. A. Benson, M.Eng., A.M.I.E.E., and R. M. Pearson, B.Eng.

(The University of Sheffield)

SUMMARY.—A simple pulse generator with a fixed repetition rate is described. The negative pulses which it produces have a time of rise of 0.8 microsecond and an amplitude of about 60 volts. The circuit can be built from a few normal laboratory components and requires no rectifier unit for it operates from an alternating voltage of about 200 V r.m.s.

Introduction

THE circuits most commonly used for the production of pulses at a fixed repetition rate work on the principle or clipping an input sine wave and passing the resultant 'square' wave through an RC differentiating circuit from which a succession of positive and negative pulses is obtained. The sequence is illustrated in Fig. 1. As shown in Fig. 2, clipping can conveniently be obtained by using either a pair of biased diodes (a) or a pentode (b) in which grid current removes the top of the positive half cycle and cut-off does the same for the negative half cycle. In both cases the time of rise of the output pulse and its amplitude are dependent on how near the output of the clipping stage approximates to a true square wave.

If the maximum amplitude of the input sine wave is V and that of the clipped wave is h (Fig. 2), then if $V \gg h$

$$\delta t \approx h/\pi V f,$$

where δt is the time taken to rise from $-h$ to $+h$ and f is the frequency.

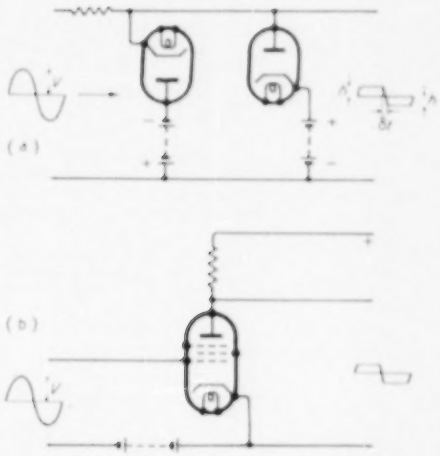
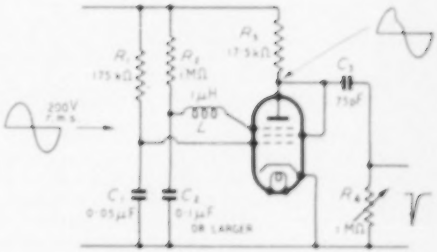


Fig. 2 (above). *Typical clipping circuits are shown: (a) is a pair of biased diodes and (b) a pentode.*

Fig. 1. *A common method of producing pulses from a sine wave is by clipping and differentiating.*

Fig. 3. (below). *Circuit of pulse generator.*



As a typical example assume $V = 250$ V and $h = 2$ V. Then a frequency of 50 c/s gives $\delta t = 50$ μsec and a frequency of 500 c/s gives $\delta t = 5$ μsec.

RC differentiation theory shows that the introduction of a voltage step with a finite time of rise produces a pulse whose rising slope is at

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best only equal to the slope of the input. Thus, to obtain a time of rise of less than a microsecond by this method the clipper output must be amplified again and reclipped.

The present article describes an alternative method employing a simple circuit which produces a succession of negative pulses at a repetition rate equal to the frequency of the input sine-wave. The pulses have a time of rise of 0·8 microsecond, an amplitude of about 60 V and an exponential decay which may be controlled by the value of the resistance in an RC differentiating circuit.

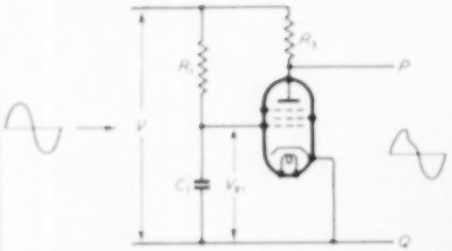
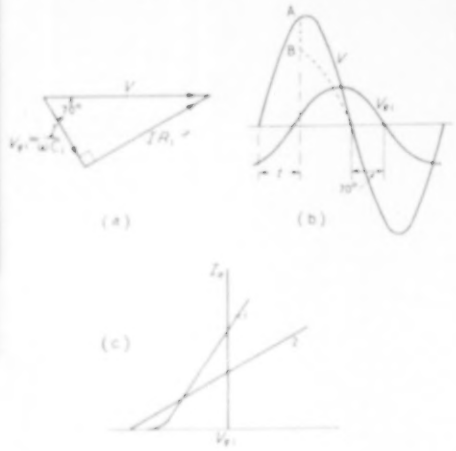


Fig. 4 (above). *Illustrating the action of the control-grid and anode circuits.*

Fig. 5 (below). *Vector diagram of the grid and anode voltages* (a). *The various voltage waveforms* (b). *Typical* I_a–V_g *curves are shown in* (c).



Circuit Arrangement

The circuit is shown in Fig. 3. The valve used is a pentode, the suppressor-grid circuit of which can be made to display negative-resistance characteristics. An alternating voltage is applied between anode and cathode of the valve. Two alternating voltages, both differing in magnitude and phase from the supply voltage, are simultaneously applied to the control and suppressor grids via R_1C_1 and R_2C_2. The action takes place on those half cycles when the anode is positive with respect to the cathode.

Consider first the part played by the control grid and associated circuit. In the simple circuit of Fig. 4 a voltage V is applied between anode and cathode. The magnitude of voltage V_{g1} applied to the control grid and its phase with respect to the anode voltage are given by the vector diagram of Fig. 5 (a). In this case the values of R_1 and C_1 are such that the voltage V_{g1} lags V by 70°. Thus considering the cycle shown in Fig. 5 (b) the valve is cut off until some time t when the grid has become sufficiently positive. At this point there is a sudden increase in anode current and the resulting anode wave-

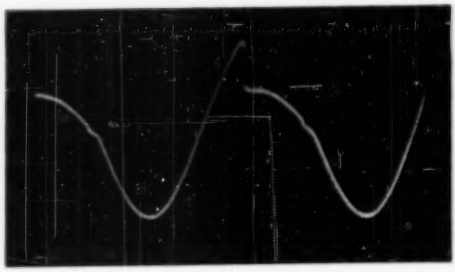


Fig. 6. *Oscillogram of anode voltage with the complete circuit of Fig. 3.*

form in shown dotted. The steepness of the voltage drop A to B depends on the slope of the I_a–V_g characteristics of the valve immediately after cut-off; i.e., a characteristic of the form (1) in Fig. 5 (c) will produce a steeper drop than will one like (2).

If a simple RC differentiating circuit is connected across P and Q of Fig. 4, pulses will be obtained due to the drop in voltage A to B in Fig. 5 (b). These pulses are of some 60 V amplitude but their time of rise is poor, being only about 20 μsec at best.

The effect of additional connections and components will now be considered. The screen grid is strapped to the anode and R_2, C_2 and L (in Fig. 3) are introduced into the suppressor-grid circuit. L, with the valve and stray capacitances to earth, forms a tuned circuit. Conditions are adjusted so that this tuned circuit executes one half cycle of a triggered relaxation oscillation, the net effect of which is to give an extremely rapid fall of suppressor voltage causing

a similar rapid fall of anode voltage within the interval A–B of Fig. 5 (b). This can be seen on the oscillograph trace of anode voltage (Fig. 6). When differentiated by R_4, C_3, pulses with very short time of rise are produced.

Fig. 7. *Output pulses superimposed on the input sine wave.*

It will be observed that this pulse is superimposed on the supply voltage as illustrated in Fig. 7. The amplitude of the sine-wave in the output, however, can be reduced to a negligible value by the correct setting of R_4.

Explanation of Triggering

A set of suppressor-grid current—grid-voltage characteristics was taken with the screen grid strapped to the anode and an anode load resistance in circuit. Results for three different anode loads are shown in Fig. 8. The characteristics are seen to possess negative-resistance regions. The shape of these regions varies greatly with the anode voltage which, in this circuit, is determined to a large extent by the value of the anode load resistor. The negative-current properties are assumed to be due to secondary emission from the suppressor-grid. If the suppressor is taken far enough positive, the current in all cases rises rapidly into the positive region after a certain point is reached, although this is not shown in all the characteristics.

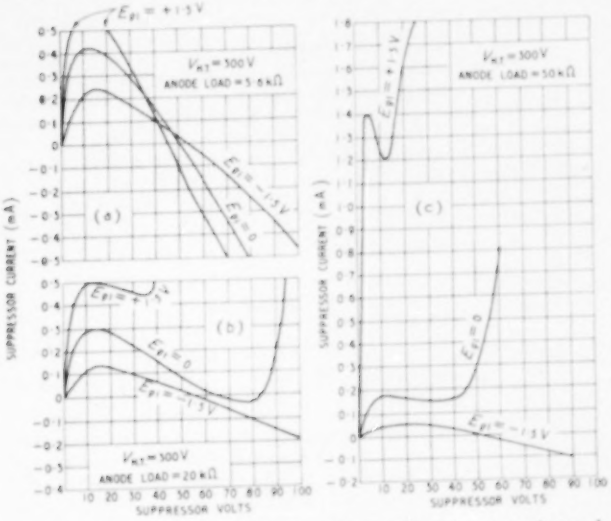


Fig. 8 (left). *Grid-current—grid-voltage curves for the suppressor grid.*

As stated previously the 1-μH inductor L forms a parallel LC circuit with the valve and stray capacitances.

Consider the suppressor-grid circuit of Fig. 9; $C_2 \gg C_0$, thus as regards any h.f. oscillations or sudden changes the point B is at cathode potential. The parallel circuit LC_0 is across a negative resistance and analysis of this type of circuit results in the differential equation :—

$$p^2 i + (1/\rho C_0 + r/L)\, pi + (r + \rho)\, i/\rho L C_0 = 0$$

where ρ is the value of the negative resistance, r the resistance of the LC_0 circuit, i the current through L and p the operator d/dt.

The solution of this equation is :—

$$i = Ke^{\alpha t} \sin(\beta t + \epsilon)$$

where $\alpha = -(1/\rho C_0 + r/L)/2$

$$\beta = \sqrt{[(r + \rho)/\rho L C_0 - (1/\rho C_0 + r/L)^2/4]}$$

and K and ϵ are constants depending on the initial conditions.

Oscillations result if $1/\rho C_0 + r/L$ is negative. They can be sinusoidal or relaxation oscillations depending on whether β is real or imaginary.

In practice a train of steep-sided relaxation oscillations results and produces the anode

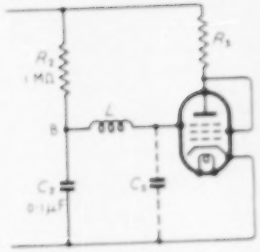


Fig. 9 (above). *Suppressor-grid circuit of the generator.*

waveform shown in Fig. 10. It starts when the LC_0 circuit receives an impulse due to the fast increase of space current in the valve when the control grid voltage emerges from the cut-off region as discussed in connection with Fig. 4. The steep side of the first oscillation cycle occurs

in the interval AB of Fig. 5(b). It is required to produce only one pulse per applied a.c. cycle, therefore phase conditions in the practical circuit are adjusted so as to inhibit all but this first half cycle. The angle of lag of the control-grid voltage behind that of the applied a.c. is adjusted so that the fast drop in anode voltage in the interval AB occurs at the instant the suppressor-grid begins to draw heavy positive

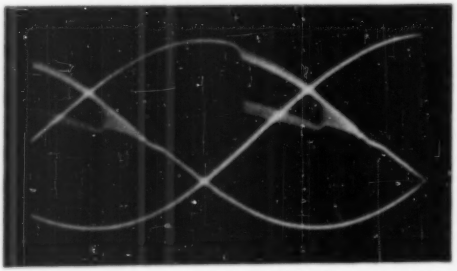


Fig. 10. *Anode-voltage waveform of the generator.*

current (this can be done by viewing the suppressor-grid waveform on an oscilloscope and adjusting R_1). When this occurs the tuned circuit LC_0 is very heavily damped. The output pulse is shown in Fig. 11.

Conclusions

The pulse generator described has the great advantage over the other types mentioned in that the only power supplies required are an a.c. one of about 200-V r.m.s. amplitude, whose frequency is equal to the required pulse repetition rate and one for the heater of the valve. Further, the circuit can be constructed from a few normal laboratory components. Thus, without any necessity for the use of a rectifier unit, and amplifiers, sharp pulses of good amplitude are easily obtained.

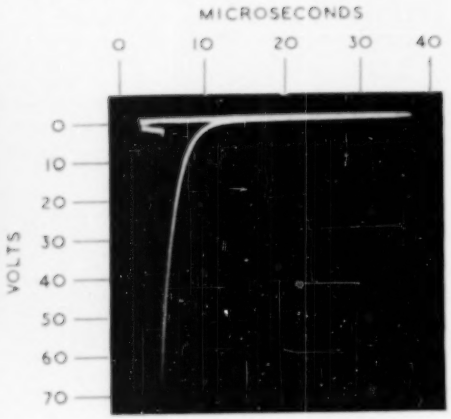


Fig. 11. *Output voltage pulse.*

Acknowledgment

The work recorded in this paper has been carried out in the Department of Electrical Engineering at the University of Sheffield. The authors wish to thank Mr. O. I. Butler, M.Sc., M.I.E.E., for facilities afforded in the laboratories of this Department.

CATHODE-FOLLOWER PERFORMANCE

Pulse and Saw-tooth Conditions

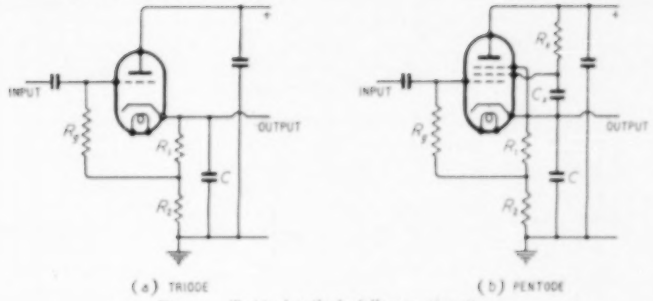
By A. J. Shimmins, B.E.E., B.Com.

(E.M.I. Engineering Development—Advanced Development)

1. Introduction

THE behaviour of cathode-follower circuits, mainly as impedance matching devices, is well known, and a considerable amount of information is available about their operation with sinusoidal signals of relatively small amplitude. It is proposed here to use Laplace-transform methods to find the factors which determine the behaviour of the circuits under pulse conditions. It will be shown that for the general case of a cathode-follower with a capacitive load, the input impedance of the circuit can be quite low to a steep-fronted input pulse in that, even with relatively small input signals, grid current will flow during the rise time of the output pulse. In addition, considerable distortion can occur to the trailing edge of the pulse if the input voltage decreases sufficiently rapidly to cause the valve to be cut off.

The distortion of voltages of saw-tooth waveforms, which are used for radar time bases, is also analysed.



(a) TRIODE (b) PENTODE

Fig. 1. *Typical cathode-follower circuits.*

2. Pulse Response

Consider a typical cathode-follower circuit with capacitive loading as shown in Fig. 1.

Assuming that the equivalent circuit of the valve is applicable (i.e., the valve characteristics are straight and parallel and equally spaced), the increment of current through R_1 and R_2 above the quiescent value is given by :—

$$r_a CR\frac{di_g}{dt} + i_g\{(\mu+1)R+r_a\} = \mu e_{in} \qquad .. \qquad (1)$$

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where

r_a = anode resistance of valve
C = shunt capacitance across load.
R = total cathode resistance $= R_1 + R_2$
μ = amplification factor
e_{in} = the applied input voltage
i_g = current increment in $R_1 + R_2$

The solution of this equation for an applied voltage of the form $e_{in} = E(1 - e^{-t/T})$ is given by :— (See Appendix 1)

$$i_g = \frac{AE}{R}\left(1 - \frac{Te^{-t/T} - T_0 e^{-t/T_0}}{T - T_0}\right)$$

Therefore $e_{out} = AE\left(1 - \frac{Te^{-t/T} - T_0 e^{-t/T_0}}{T - T_0}\right)$ (2)

where

T = time constant of the input voltage
$T_0 = R_0 C$ = time constant of output impedance and load capacitance. R_0, the output impedance, is equal to $\frac{Rr_a}{(\mu+1)R + r_a}$
A = gain of cathode-follower.
$= \frac{\mu R}{(\mu+1)R + r_a}$

Equation (2) is perfectly general and gives the change in cathode voltage above or below the quiescent value for a specified change in input voltage of known time constant T. When t is large so that the exponential components have decayed, the output voltage tends to AE. (E is the maximum value of the input voltage.)

3. Response to Positive Step

In this case E is positive and corresponds to the leading edge of a positive pulse or the trailing edge of a negative pulse. For the particular case of a step function input, $T = 0$ and

$$e_{out} = AE\,(1 - e^{-t/T_0}) \qquad .. \qquad .. \qquad .. \qquad (3)$$

and the output is an exponential rise of time constant equal to $R_0 C$.

The output responses for two input voltages of different rise times are given in Fig. 2(a) and (b). It should be noted that if T is greater than

about 5 times T_0, the output voltage follows the input voltage fairly closely.

From Fig. 2 it can be seen that if T is of the same order as T_0 the cathode potential cannot follow the grid voltage immediately. Consequently, the grid becomes positive and grid current flows, until the cathode voltage builds up and exceeds the grid voltage.

For a large step function input, grid current flows (with consequent low input impedance) for a time approximately 3 times the time constant T_0 of the output circuit.

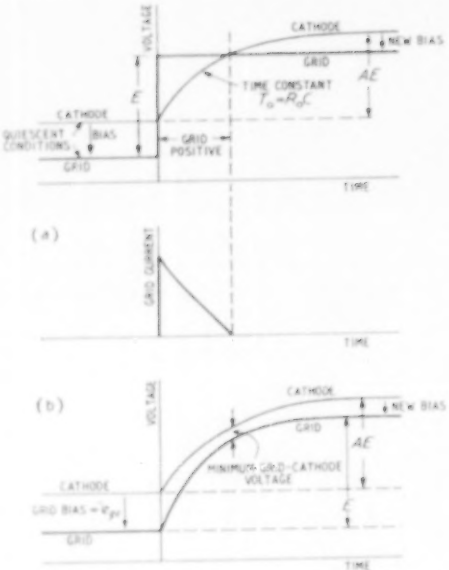

Fig. 2. *Response to a step function (a) and to an exponential rise at the grid (b).*

It can be shown that the necessary condition for grid current to flow is given by :—

$$E(1-A) \geqslant e_{gc} + E\left(e^{-t/T} - A\frac{e^{-t/T} - T_0/Te^{-t/T_0}}{1 - T_0/T}\right) \quad \ldots \quad (4)$$

where e_{gc} is the grid-cathode voltage before application of the input pulse, and the other symbols have the same meaning as in equation (2), and that the most likely time for grid current to flow, or the time when the grid current is a maximum, is given by :—

$$t = \frac{T_0 T \log_e (T_0/TA - 1/A + 1)}{T_0 - T} \text{ sec} \quad \ldots \quad (5)$$

after the application of the input pulse. If $T = 0$ (a step function) the maximum current is at the beginning of the pulse.

4. Response to Negative Step

If a negative step, corresponding to the trailing edge of a positive pulse or the leading edge of a negative pulse, is applied to the grid of a cathode-follower, equation (2) still holds, but in this case E is negative. The changes in grid and cathode voltage after the application of an exponentially increasing pulse are shown in Fig. 3.

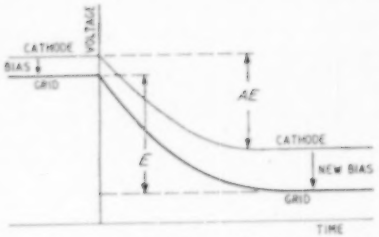

Fig. 3. *Changes in cathode voltage after application of a negative exponential change at the grid.*

If e_{gc} is the initial grid-cathode voltage on the valve just before the application of the pulse then at any time t after the application of a voltage $e = -E(1 - e^{-t/T})$ to the input, the grid-cathode voltage is given by :

$$E_{gc} = e_{gc} + E(1-A) - \frac{Ee^{-t/T}(1 - T_0/T - A) + AT_0/Te^{-t/T_0}}{1 - T_0/T} \quad (6)$$

where the symbols have the same definitions as in equations (2) and (3).

For the particular case where $T = 0$ (i.e., for a negative step function) we have the conditions indicated in Fig. 4.

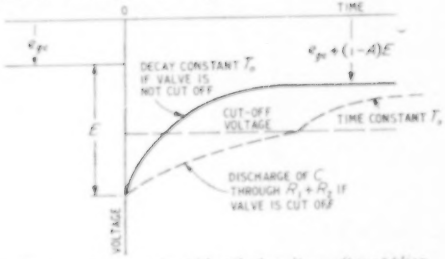

Fig. 4. *Changes in grid-cathode voltage after application of a negative step change of amplitude E.*

If at any time this voltage exceeds the cut-off voltage of the valve, the valve will become an open circuit and the capacitance C will discharge through the resistances R_1 and R_2 until the grid-cathode voltage decreases to the cut-off value, after which decay is at a time constant T_0. This obviously represents considerable distortion of a negative signal.

5. Effect of a Series Grid Resistor

If grid current is limited on positive input pulses by the existence of a series grid resistor, then the cathode-grid voltage is held at a slightly positive value and anode current flow will be limited. Under such conditions it can be shown that (Appendix 2) :—

$$e_{out} = \frac{\mu e_{cc} R}{R + r_a}\left\{1 - \exp\left(-t\frac{R + r_a}{CRr_a}\right)\right\} \qquad (7)$$

for a step function applied at the input.

This rise, which has a time constant much lower than T_0, will continue until the grid-cathode voltage becomes negative, after which the time constant T_0 is applicable.

Fig. 5 shows these changes in cathode and grid voltages. When the step voltage is applied to the input, the grid voltage rises immediately to the cathode voltage, after which the grid and cathode voltages both rise exponentially, the grid being slightly positive with respect to cathode. The difference between the input

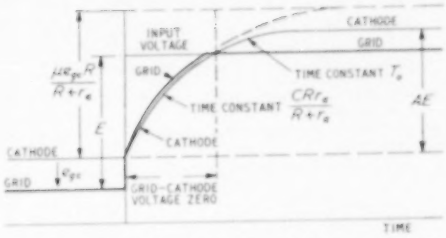

Fig. 5. *Response of cathode voltage with a step function at the input, with high grid circuit impedance.*

and grid voltage appears across the series grid resistor. If the input voltage is E volts, the time at which the input and grid voltages are equal is readily determined, after which the conditions given by equation (7) cease to apply, the grid remaining at the input voltage and the cathode voltage rising with a time constant T_0 until the new operating bias on the valve is developed. The final cathode voltage rise will, of course, be AE, A being the gain of the cathode-follower as defined in equation (2) and E is the applied input voltage.

Fig. 6. *A constant change function.*

6. Response to Constant Change Function

We will now consider the response of a cathode-follower to a constant-change function as shown in Fig. 6. This is a common time-base waveform.

If a voltage $E = kt$ is applied to the input, it can be shown that the output voltage is given by :—(Appendix 3.)

$$e_{out} = Ak\{t - T_0(1 - e^{-t/T_0})\} \qquad (8)$$

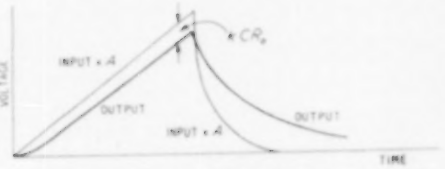

Fig. 7. *Output voltage for input shown in Fig. 6.*

A graph of this function and the input function is given in Fig. 7. It can be seen that after a short time the output voltage is a linear function of time but lags behind the input voltage by an amount which depends on the rate of change of the input voltage and the time constant of the cathode load.

At any time t we have :—

Proportion lag in output voltage =

$$\frac{AE - e_{out}}{AE} = \frac{CR_0}{t}(1 - e^{-t/R_0C}) \qquad (9)$$

The exponential term decays rapidly, and AE the output voltage then lags kCR_0 volts behind Akt, the ideal output voltage. The behaviour on the trailing edge is treated in Section 4 above.

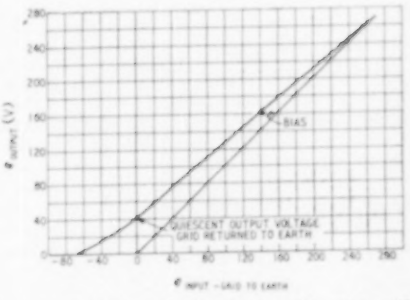

Fig. 8. *Output-input voltages for 6L6 valve with 400-V supply and 4,000 ohms load.*

7. A Typical Example

Consider as an example a cathode-follower consisting of a 6L6 valve with a 400-volt d.c. supply and a cathode load of 4,000 ohms.

The published constants of this valve are :

$g_m = 4.7$ mA/volt

$r_a = 1{,}700$ ohms

$\mu = 8$

$R_m = 1/g_m = 213$ ohms.

From the anode characteristics of the valve, with a loadline of 4,000 ohms, Table I can be prepared.

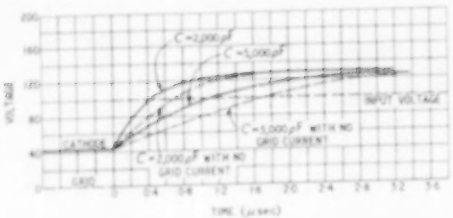

Fig. 9. *Rise of cathode voltage for a step function on the grid.*

TABLE I

Grid Voltage	Anode Current (mA)	Voltage across Valve	Voltage across Load
0	58	130	270
7.5	58	170	230
15	46	216	184
22.5	35	260	140
30	28	288	112
37.5	19	324	76
45	12	352	48
52.5	6	376	24
60	3	382	18
65	0	400	0

The calculated gain is 0.85 and the output impedance is 180 ohms. Fig. 8 is a graph of output voltage against input voltage. For a step function of 100 volts applied to the grid, the cathode voltage for loads of 5,000 and 2,000 pF are given in Fig. 9, the time constant of the output voltages for the two cases are 0.9 μsec and 0.36 μsec respectively, and grid current flows for 1.08 μsec and 0.40 μsec for the two cases. If grid current is limited by the addition of a resistor of, say, 100 kΩ in the grid circuit the output voltages are given by the dotted curves in Fig. 9. The rates of rise are 236 volts per microsecond when grid current flows and 98 volts per microsecond when grid current is limited (2,000 pF load) and 94 V/μsec and 39 V/μsec for the corresponding conditions with a load of 5,000 pF. The response is about 2.4 times as fast when grid current flows.

8. Conclusion

The equations developed and given above enable the performance of cathode-followers under pulse conditions to be calculated. The effect of grid-cathode capacitance has not been considered, but it is hoped to consider this in another article. In general, this capacitance is small compared with the load capacitance and has no effect on the above results.

APPENDIX 1

Change of output voltage for a given input voltage.

Consider the circuits of Fig. 10 :—

Let i be the instantaneous anode current, which has a component i_g in the cathode resistor and i_c in the capacitance

$$i = i_g + i_c$$

we have :—

$$\mu e_g = i_g R + i r_a = i_g R + (i_g + i_c) r_a$$

and

$$\begin{cases} i_c = c \dfrac{de_{out}}{dt} = C \dfrac{d(i_g R)}{dt} = CR \dfrac{di_g}{dt} \\ e_g = e_{in} - i_g R \end{cases}$$

therefore :—

$$\mu(e_{in} - i_g R) = i_g (R + r_a) + CR\, r_a \frac{di_g}{dt}$$

$$CR r_a \frac{di_g}{dt} + i_g[(\mu + 1) R + r_a] = \mu e_{in}$$

Assume that the input voltage is an exponential rise function given by $e = E(1 - e^{-t/T})$ This includes as a particular case (when $T = 0$) the step function.

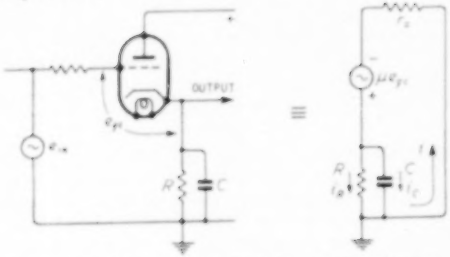

Fig. 10. *Actual and equivalent circuits showing division of anode current between cathode resistor and load capacitance.*

Taking Laplace transforms[1] of both sides we have :—

$$CR r_a\, pI_g + I_g[(\mu + 1)R + r_a] = \mu E \left(1 - \frac{p}{p + 1/T}\right)$$

$$\text{or } I_g = \frac{\mu E \left(1 - \dfrac{p}{p + 1/T}\right)}{CR r_a\, p + (\mu + 1) R + r_a}, \text{ where } I_g \text{ is the transform of current } i_g.$$

$$I_g = \frac{\mu E}{CR r_a\, p + (\mu + 1) R + r_a} - \frac{\mu E p}{(p + 1/T)[CR r_a p + (\mu + 1) R + r_a]}$$

[1] The Laplace transforms used here are given in "Applied Mathematics for Engineers and Physicists," L. A. Pipe, McGraw Hill Book Company. Tables page 130.

Taking inverse transforms :—

$$i_g = \frac{\mu E}{R(\mu+1)+r_a}\left[1-\exp\left(-\frac{R(\mu+1)+r_a}{CRr_a}t\right)\right]$$
$$-\mu E\,\frac{\exp\left(-\frac{R(\mu+1)+r_a}{CRr_a}t\right)-\exp(-t/T)}{\frac{CRr_a}{T}-R(\mu+1)-r_a}$$

If we introduce the well-known formulae for gain and output impedance :—

$$A = \frac{\mu R}{(\mu+1)R+r_a}$$

$$R_o = \frac{r_a R}{(\mu+1)R+r_a}$$

and putting $T_0 = CR_0$ we have :—

$$e_{out} = i_g R = AE(1-e^{-t/T_0}) - AE\,\frac{(e^{-t/T_0}-e^{-t/T})}{T_0/T-1}$$
$$= AE\left(1-\frac{T_0 e^{-t/T_0}-Te^{-t/T}}{T_0-T}\right)$$

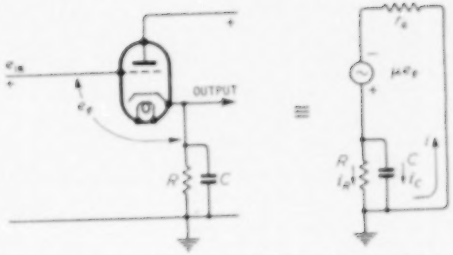

Fig. 11. *Actual and equivalent circuits with series grid resistor.*

APPENDIX 2

Conditions existing when grid is prevented from drawing current.

We have the equivalent circuit of Fig. 11.

If there is a large series grid resistor, then if e_{gc} is the bias on the valve before the application of the input pulse, we have:—

$$\mu e_{gc} = i_g R + (i_g + i_c) r_a$$
$$i_c = CR\frac{di_g}{dt}$$
$$\therefore CRr_a\frac{di_g}{dt} + i_g(r_a - R) = \mu e_{gc}$$

Taking Laplace Transforms :—

$$I_g = \frac{\mu e_{gc}}{CRr_a p + r_a + R}$$

which yields a solution

$$i_g = \frac{\mu e_{gc}}{r_a+R}\left[1-\exp\left(-\frac{R+r_a}{CRr_a}t\right)\right]$$

or $$e_{out} = \frac{\mu e_{gc}}{R+r_a}R\left[1-\exp\left(-\frac{R+r_a}{CRr_a}t\right)\right]$$

This will hold until the grid becomes negative, after which the time constant T_0 is applicable, as shown in Fig. 5.

APPENDIX 3

Response of cathode-follower to a constant change function.

Here equation (1) in the text is applicable and e_{in} is equal to kt.

Thus we have :—

$$r_a CR\frac{di_g}{dt} + i_g[(\mu+1)R + r_a] = \mu kt$$

Taking Laplace transforms of both sides we have :—

$$r_a CR\,pI_g + I_g[(\mu+1)R + r_a] = \frac{\mu k}{p}$$

$$\text{or } I_g = \frac{\mu k}{p\,r_a CR\left(p + \frac{(\mu+1)R + r_a}{r_a CR}\right)}$$

where I_g is the Laplace transform of the current i_g. Taking inverse transforms we have :—

$$i_g = \frac{\mu k}{r_a CR}\left[\frac{tr_a CR}{(\mu+1)R + r_a} - \frac{(r_a CR)^2}{[(\mu+1)R + r_a]^2}\left\{1-\exp\left(-\frac{(\mu+1)R + r_a}{r_a CR}t\right)\right\}\right]$$

gives the output voltage as a function of time.

If we again introduce the formulae for gain A and output impedance R_0, as given in Appendix 1, we have :—

$$e_{out} = Ak[t - R_0 C\{1 - e^{-t/R_0 C}\}]$$
$$e_{out} = Ak[t - T_0\{1 - e^{-t/T_0}\}]$$

which gives the output voltage as a function of time, the ideal output voltage (when $C = 0$) being Akt or A times the input voltage.

INTERFERENCE IN MULTI-CHANNEL CIRCUITS

Dependence on Harmonic Generation

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SUMMARY. On the assumption that the relation between output and input for any unit of the link can be represented as a power series of the input signal, suitably delayed, the harmonic content of the output for a pure tone input signal is found. When a multi-channel signal is injected it is found that the inter-channel interference falling in any particular channel consists of a number of separate terms, each bearing a functional relation to a corresponding harmonic component of the output when a pure tone test signal is used as input. This relation is found in the form of an integral in which the r.m.s. amplitude of the pure tone input occurs as a variable of integration. Hence, to find the interference level, the harmonics have to be measured over a range of values of input amplitude, and the interference components deduced by a somewhat involved analysis. Only in the case in which the second and third harmonics predominate is this procedure unnecessary, and there is then a direct and simple relation between interference and harmonics. This latter construction confirms the standard procedure for finding the interference level in this region. Otherwise, the paper is at variance with other published work, in that the latter neglects the effects of coherence, which are here considered in detail.

A particular case—distortion due to mis-matches on a long feeder line—is investigated in detail, and it is shown that, for increasing feeder length, the interference and second harmonic at first increase together, but that, for long feeder lengths, the former decreases slowly while the latter passes through a maximum and then oscillates, its place as the dominant harmonic being taken first by the third, and then successively by higher harmonics. It is shown that, in this example, both the second and third harmonics could vanish for certain feeder lengths, although the interference could remain at an appreciable level, so that caution is necessary before accepting small absolute values of harmonics at their face value. In this connection, the importance of small variations of feeder length or of carrier frequency in determinations of interference levels, is stressed.

It is shown that the beat-frequency method of harmonic measurement, at present in use, although convenient from several points of view, is not exactly equivalent to a determination of the harmonic levels and cannot be used for the analysis of this paper. The two methods are equivalent, however, when the second and third harmonics can be shown to be the only significant ones, in which case, as already stated, the relationship with the interference level is straightforward.

1. Introduction

ONE of the most important characteristics of the performance of a multi-channel link is the inter-channel interference level. It is not normally possible to measure this directly in test, as a suitable multi-channel source is not likely to be available. Instead, a pure tone signal can be injected, and the harmonic margin measured. This harmonic level is then usually taken as an indication of the interference level to be expected from the working link. The purpose of this paper is to examine in detail the connection between the harmonic level on the one hand, and the performance of the link on the other, and to suggest a precise test procedure for relating the two.

2. Harmonic Production

We shall confine ourselves, for the most part, to the multi-channel signal, which will be at "video" frequency. In this band it will be assumed that the relation between output and input signals for any unit of the link can be represented by a power series

$$V = a_1 s + a_2 s^2 + \ldots \quad \ldots \quad \ldots \quad (1)$$

MS accepted by the Editor, January 1950

where $s = s(t)$ is the input signal, either multi-channel, or test. There will in general, be a time delay τ, so that s in Equ. (1) is really $s(t - \tau)$. This delay can be ignored provided, of course, it is the same delay which occurs in each power of s. An exception can be made, however, for the term $a_1 s$, which represents the recovered signal, and which will normally be much larger than the other (distortion) terms. Since we are concerned with the distortion level relative to the recovered signal level, it is only the amplitude of the latter which is of interest so that its phase can be ignored. But all of the distortion terms combine together to give the various harmonics, and hence their relative phase is important.

In what follows, it will be understood, to save repetition, that all harmonic and interference levels are referred to their respective signal levels.

If we put $s = x\sqrt{2}\cos qt$, to represent a pure tone test signal, into Equ. (1), x being the r.m.s. level, we get

$$V = a_1 x\sqrt{2}\,[\cos(qt) + \sum_{1}^{\infty} f_n(x)\cos(nqt)] \quad (2)$$

The amplitude $f_n(x)$, which is a function both of the coefficients of Equ. (1) and the r.m.s. value

of the signal, x, is obtained in Appendix 1. It represents the harmonic margin of the n^{th} harmonic of frequency nq, and is the quantity which can be measured in a straightforward way in test. For example, if with a certain input signal level, $f_2(x)$ is measured as 10^{-3}, then the second harmonic is $20 \log_{10}(10^{-3}) = 60$-db down on the recovered signal (which appears, of course, in a different part of the band).

The harmonic amplitudes $f_n(x)$ vary with the r.m.s. input signal amplitude, x, and all obviously vanish at $x = 0$. Their actual behaviour as x varies turns out to be important in relating them to the inter-channel-interference level.

3. Multi-Channel Signal

Let there be N channels (N large) equispaced in frequency by an amount p c/s, so that the 'video' frequency of the n^{th} channel is np. Then a multi-channel signal can be represented by

$$S = x\sqrt{2/\alpha N} \sum_{1}^{N} \epsilon_n \cos(npt + \theta_n) \quad \ldots \quad (3)$$

It is here assumed, for simplicity, that the channels start at $n = 1$, but the ensuing analysis may be used if a small number at the bottom are missing, provided N is increased by a corresponding amount.

θ_n is a random phase angle, which ensures incoherence between different channels. ϵ_n is a quantity which is 1 or 0 according to whether the n^{th} channel is working or not.

We assume $\sum_{1}^{N} \epsilon_n = \alpha N$, so that α is the fraction of channels actually transmitting at any given moment. (Approximately, half the channels will not be in use, owing to waiting, dialling, etc., while of those in use, roughly a half will be listening, and therefore not transmitting. α may therefore be taken to be about a quarter.)

Since $\epsilon_n^2 = \epsilon_n$ (both being either 0 or 1), the r.m.s. of the signal of Equ. (3) is

$$\sqrt{(2x^2/\alpha N) \sum_{1}^{N} \tfrac{1}{2}\epsilon_n^2} = \sqrt{(2x^2/\alpha N)\tfrac{1}{2}\alpha N} = x.$$

However, the signal level of a working channel is $x\sqrt{2/\alpha N}$, and it is to this level that the interference will be referred.

4. Generation of Inter-channel Interference

Let us confine our interest to the r^{th} channel, and define a quantity $y = r/N$; y defines the position of the r^{th} channel, is zero at the bottom, and 1 at the top of the band of channels.

Let us substitute in Equ. (1) the multi-channel signal of Equ. (3), multiply out, and convert products of cosine terms to sum and difference terms. All those whose resultant frequency falls in the r^{th} channel can be picked out, and constitute the interference in that channel.

At first sight it would appear that all such terms would be incoherent, thus adding up 'power-wise' to give the total interference, but this is not the case. A detailed analysis reveals that they fall into groups with a certain amount of coherence within a group, and with no term in any one group coherent with any term in any other group. The amplitude of the n^{th} group is denoted by $g_n(x)$ and is a function of the r.m.s. amplitude x, of the multi-channel signal of Equ. (3). $g_n(x)$ is related, though not in a very simple way, to the function $f_n(x)$ discussed in Section 2. For this reason $g_n(x)$ can conveniently be referred to as the n^{th} harmonic component of the interference. It should be understood, however, that this nomenclature is only by analogy with $f_n(x)$, and is not intended in any way to describe the method of formation of the group. As described above, each group is generated by beat frequencies of all orders and from all channels, and it is, perhaps, a matter of surprise that there is such a definite segregation of terms into groups.

5. Relation Between $g_n(x)$ and $f_n(x)$

We are interested in the r^{th} channel, and in order to find the harmonics produced in this channel by a pure tone input of frequency q, we take $q = \frac{1}{2}rp$ for the second harmonic, $q = \frac{1}{3}rp$ for the third, and so on. Then an input of $x\sqrt{2}\cos(rpt/n)$ will produce in the r^{th} channel its n^{th} harmonic of amplitude $f_n(x)$ (relative to the fundamental which appears, of course, in the channel r/n). It is this quantity $f_n(x)$ which will be related to that part of the component of interference $g_n(x)$, which falls in the r^{th} channel. $g_n(x)$, as already stated, is referred to the level of the channel signal, so that, when it is found, the total interference margin $G(x)$ in the r^{th} channel, can be found from $G^2(x) = \sum_{2}^{\infty} g_n^2(x)$.

The power-wise addition follows from the mutual incoherence between the groups. $G(x)$ will, of course, also be a function of $y = r/N$ which gives the channel position, so that the interference will, in general, vary (smoothly) from channel to channel. Normally, only the first few harmonics $f_n(x)$ will be significant, so that the number of $g_n(x)$ to be summed is correspondingly few.

In Appendix 2 it is shown that

$$g_2(x) = \sqrt{4x(1 - y/2)}\,\frac{1}{x^3}\int_0^\infty f_2(z)e^{-x^2/4}z^4dz \qquad (4)$$

$4x$ can usually be replaced by unity, while the factor $\sqrt{1 - y/2}$ shows a variation of 0.7 : 1 ≡ 3 db from the top to the bottom of the band of channels. For the r^{th} channel we simple insert the value of $y = r/N$. To calculate $g_2(x)$, which is the amplitude of the second-harmonic component of interference for the r^{th} channel, it is first necessary to measure $f_2(z)$ over as wide a range of r.m.s. amplitude, z, as the experimental procedure may permit. A single tone of frequency $\frac{1}{2}\,rp$ is injected, and its r.m.s. varied as just described. The value of harmonic appearing in the channel r referred to the fundamental appearing in the channel $r/2$ is the function $f_2(z)$ required. This value must be inserted into Equ. (4), into which has also been put the correct value of x, the r.m.s. value at which the total muli-channel signal is intended to operate.

The integration may be performed graphically; or by fitting the measured $f_2(z)$ with a polynomical of the form $b_1z + b_3z^3 + b_5z^5 + \ldots$, only odd powers appearing. In either case, it is necessary to check that the largest value of z which has been reached is sufficient for the factor $e^{-x^2/4}$ to have reduced the integrand to a small enough value to justify neglecting the contribution from the rest of the range. It is easily shown that

$$\int_0^\infty z^{2n+1}e^{-x^2/4}dz = n!\;x^{2n+2}/2, \text{ whence we}$$

have the following particular values.

$$\int_0^\infty z^5e^{-x^2/4}dz = x^6\,; \quad \int_0^\infty z^7e^{-x^2/4}dz = 3x^8\,;$$

$$\int_0^\infty z^9e^{-x^2/4}dz = 12x^{10}\,; \quad \int_0^\infty z^{11}e^{-x^2/4}dz = 60x^{12}\,;$$

$$\int_0^\infty z^{13}e^{-x^2/4}dz = 360x^{14}\,; \text{ etc.}$$

Hence, when $f_2(z) = b_1z + b_3z^3 + b_5z^5 + \ldots$ we get

$$g_2(x) = \sqrt{4x(1 - y/2)}[b_1x + 3b_3x^3 + 12b_5x^5 + \ldots] \qquad (5)$$

In particular, when x is small enough, it is seen that, apart from the factor $\sqrt{4x(1 - y/2)}$, the first terms of g_2 and f_2 are the same. Hence, for sufficiently small values of x we have

$$g_2(x) \approx \sqrt{4x(1 - y/2)}f_2(x), \; x \text{ small} \qquad (6)$$

The order of approximation is that the fourth and higher harmonics be negligible compared to the second. Unless this is so, the full Equs. (4) or (5) must be used. When Equ. (6) can be used it is not necessary, of course, to measure $f_2(x)$ over a range of values since the integration of Equ. (4) is no longer called for.

The function $g_3(x)$ is similarly found to be given by

$$g_3(x) = \sqrt{4x(1 - y^2/3)/2}\,\frac{1}{x^6}\int_0^\infty f_3(z)e^{-x^2/4}z^5dz \qquad (7)$$

As before, $f_3(z)$ must be measured over a range of values of z, a fundamental of frequency $rp/3$ being used. $f_3(z)$ is obtained by referring the amplitude of the 3rd harmonic appearing in the r^{th} channel to the fundamental which now appears in the channel $r/3$. $f_3(z)$ can be fitted by the expansion $b_3z^3 + b_5z^5 + b_7z^7 + \ldots$, giving

$$g_3(x) = \sqrt{4x(1 - y^2/3)/2}\,[3b_3x^2 + 12b_5x^4 + 60b_7x^6 + \ldots] \qquad (8)$$

When x is small enough we get the approximation, from the first term only,

$$g_3(x) \approx (3/\sqrt{2})\sqrt{4x(1 - y^2/3)}f_3(x), \; x \text{ small} \qquad (9)$$

The order of the approximation is the same as for Equ. (7). When this is satisfied, the higher g_n are then negligible, so that we have the approximation

$$G(x) \approx \sqrt{4x}\,(1 - y/2)f_2^2(x) + (9/2)(1 - y^2/3)f_3^2(x)], \; x \text{ small} \qquad (10)$$

In general,

$$g_n(x) = [\sqrt{4xh_n(y)}/x^{n+2}]\int_0^\infty f_n(z)e^{-x^2/4}z^{n+2}dz$$

$$\text{with } h_n(y) = \frac{2^n}{\pi\,n!}\int_0^\infty \cos y\theta\left(\frac{\sin\theta}{\theta}\right)^n d\theta \qquad (11)$$

Particular values are

$h_2(y) = 1 - y/2\,;\; h_3(y) = (1 - y^2/3)/2\,;$
$h_4(y) = (8/9 - y^2/3 + y^3/12)/4\,;$
$h_5(y) = (46 - 12y^2 + 6/5y^4)/(24)^2$

$f_n(z)$ may be approximated by a polynomial commencing with the term $b_{n-1}z^{n-1}$, successive terms having exponents of z increasing by 2. The integrations can, of course, be done graphically.

6. Comparison with Published Results

Comparison will here be made with the paper by Brockbank and Wass[1], which treats all orders of distortion in some detail. Although the approximate formula (10) above is in general agreement with the results of the same order in the above paper, there is no reference there to the semi-coherent groups, $g_n(x)$, and their relation to $f_n(x)$. The reason can be found in the paragraph (9.3) " Low-Order Products from High-Order terms " in which it is stated " It can be shown that, although the power in each such low-order product may exceed the power in each higher order product, the number of products is

so much lower when N is not small that the total distortion power in the higher order products is considerably greater than the power in the lower-order products." They have, therefore, neglected these low-order products. What has not been realized is that these low-order products are *coherent* with other terms that are not negligible, and that these terms and the low-order products will therefore add up voltage-wise and not power-wise. The effect, as found here, is to make the effects of the low-order and high-order products of the same order of magnitude, so that agreement is limited to the region in which all such products can be neglected. This leads to Equ. (10).

As stated above, the occurrence of coherent groups is quite unexpected, and they can only be determined by a very detailed analysis. That they must occur is apparent when it is realized that such a term as, for example $(A + B - C)$ in a third-order product, is repeated identically in frequency *and phase* in a fifth-order product which gives such a term as $(A + B - C + D - D) = (A + B - C)$. The writer is not aware if such an effect has already been treated in the literature, but it seems necessary that when higher-order harmonics have to be treated, that the analysis follow closely that outlined here.

7. Coherence with the Main Signal

The odd-harmonic interference components are peculiar in that part of each of them undergoes a phase change of exactly ϕ when each individual term undergoes this same change. Thus if we consider the expanded form of the product $\cos(lpt + \phi) \cos(mpt + \phi) \cos(npt + \phi)$ one of the terms will be of the form $\cos\{(lpt + \phi) + (mpt + \phi) - (npt + \phi)\} = \cos\{(l + m - n)pt + \phi\}$ which is seen to have changed by the same amount ϕ. If the main signal also undergoes this same change ϕ, it follows that part of the interference terms remain in phase with the main signal, and hence will add up voltage-wise rather than power-wise as the signals are transmitted from repeater to repeater. *In any particular case, however, it must be checked whether the main signal really does alter by the same phase angle, as even a small variation will destroy the coherence effect.* In the next section an example is treated in which a phase difference actually is introduced between the main signal and the interference components, such that the odd-harmonic components no longer give coherence with the main signal.

As an example of the separation of cross-talk components let us investigate the third-harmonic component of interference $\bar{g}_3(x)$. Then it is shown in the Appendix

$$\bar{g}_3(x) = \sqrt{x(1 + 2y - 2y^2)} \cdot \frac{1}{x^6}\int_0^\infty f_3(z)e^{-x^{1/3}z^{1/3}}z^5dz$$

Hence

$$\bar{g}_3(x)/g_3(x) = \sqrt{(1 + 2y - 2y^2)/2(1 - y^2/3)} \quad (11)$$

a result that depends only on the position, y, of the channel. The right-hand side of Equ. (11) varies from 0.71 at $y = 0$ to a maximum of 0.92 at $y = 0.7$ and down to 0.87 at $y = 1$. Thus nearly the whole of $g_3(x)$ is of this 'in phase' type, and may add up voltage-wise from repeater to repeater.

8. Distortion from a Mis-matched Feeder

Unless the analytic form of the output of Equ. (1) is known, the general analysis cannot be taken any further, and the results so far presented are intended for application when the various functions $f_n(x)$ have been determined experimentally.

However, a particular case which is capable of complete treatment is that caused by phase distortion due to a mis-matching at the end of a long feeder line. In a previous paper[2] on this subject the function $f_n(x)$ for this case was determined.

A frequency-modulated signal is transmitted from a long feeder, but owing to mis-matches at its ends, multiple reflections are set up within the feeder. These cause a phase distortion of the transmitted wave, and in Equ. (3) the expected output is shown to be given by

$$V = \Delta\omega \sin(\omega_a t) - \delta$$

$$\delta = \frac{d}{dt}\{kr_1r_2 \sin(2\omega_c\tau - \theta_1 - \theta_2 + 2\tau\Delta\omega \cdot \sin(\omega_a t - \tau) \sin(\omega_a\tau)/\omega_a\tau)\} \quad (13)$$

Here, ω_c is the r.f. carrier and $\Delta\omega \sin \omega_a t$ is the pure tone input signal, which is recovered together with distortion terms; the latter are represented by the second term in Equ. (13). r_1 and r_2, and θ_1 and θ_2 are respectively the amplitudes and phase angles of the reflection coefficients at each end of the feeder. τ is the time delay along the feeder, and equals l/v where l is the feeder length and v the group velocity of the waves. k is the attenuation along the double length of feeder and equals $e^{-2\alpha l}$ where α is the attenuation coefficient.

Equ. (13) has to be compared with Equ. (1) with $s = \Delta\omega \sin \omega_a t$—the r.m.s. amplitude x being given by $\Delta\omega = x\sqrt{2}$. It is seen that Equ. (13) as it stands is not capable of expansion in powers of s, owing to (1) the presence of $\sin(\omega_a\tau)/\omega_a\tau$, which contains ω_a, a characteristic of the signal: (2) the occurrence of $t - \tau$ instead of t in the

distortion terms, and (3) the operator d/dt. ω_s is the video frequency and is usually not very high so that unless the feeder run is so large that it becomes comparable with the wavelength of the video-frequency, $\omega_s\tau$ will be small. Hence $\sin(\omega_s\tau)/\omega_s\tau$ can be replaced by unity without serious effect, and point (1) above is no longer a limitation.

Point (2) is covered by Section (2), which permits all powers of s above the first to contain a constant delay. However, since the recovered signal in Equ. (13) contains no delay, the distortion terms, although coherent with the main signal, will differ in phase from it by an angle $\omega_s\tau$. (That such a delay must occur is apparent when it is realized that the distortion terms arise from waves that have been reflected down the feeder and back again before transmission). Hence the 'in-phase' components of odd-order interference harmonics, although coherent with the main signal, are not actually in phase with it, and the phase difference changes from repeater to repeater, giving the appearance of a random phase change. Thus for all practical purposes, this component behaves as if it were incoherent, and there is no call to extract it from the rest of the interference terms for special treatment. It will not add up voltage-wise from repeater to repeater.

So far as the operator d/dt is concerned, if it were applied at the end of the analysis, no alteration would be called for. It would produce merely a factor, which for Equ. (13), would be $n\omega_s$ for the n^{th} harmonic; and which, in the multi-channel case, would be rp for the r^{th} channel. Hence, if we quote results in which d/dt has been applied at an earlier stage, the only change necessary is the replacement of $n\omega_s$ by rp.

The functions $f_n(x)$ for this problem are easily obtained from Equ. (13) by the Fourier-Bessel expansion, and are given in Equ. (5) of the paper referred to. Replacing $n\omega_s$ by rp as discussed above we get

$$f_n(x) = kr_1r_2(rp)\frac{J_n(x2\sqrt{2\tau})}{x}\left[\sqrt{2}\begin{matrix}\sin\\\cos\end{matrix}(2\omega_c\tau - \theta_1 - \theta_2)\right] \quad .. \quad (14)$$

The sin or cos occurs according to whether n is even or odd. Since the phase angle $2\omega_c\tau - \theta_1 - \theta_2$ is indeterminate without a precise knowledge of the particular arrangement in use, we can, in considering over-all behaviour of many units, replace the terms in square brackets by their r.m.s., in this case unity. However, this is only an average effect, and for any particular feeder at any one repeater this term will be quite definite, and only if $2\omega_c\tau - \theta_1 - \theta_2$ reduces to 45° will the results be the same. But the effects of different repeaters, or of the same repeater under slightly different conditions of temperature, etc., can be simulated by a variation of $\omega_c\tau$. This can be conveniently done either by small changes of ω_c or by varying τ, by means of a line lengthener. In the ensuing analysis the results will be averaged out by taking the r.m.s. for the indeterminate phase term, but the above statement must be borne in mind in the interpretation of any single result.

Accordingly, we take for $f_n(x)$

$$f_n(x) = kr_1r_2(rp)J_n(x2\sqrt{2\tau})/x \quad .. \quad (15)$$

The integrations required by Equ. (11) can be performed by means of the following integral[3]

$$\int_0^\infty J_n(at)e^{-t^2}t^{n+1}dt = a^n\left(\frac{a^2}{2}\right)^{n+1}e^{-a^2/4}$$

Hence, using Equs. (11) and (15), we get

$$g_n(x) = \frac{kr_1r_2(rp)}{x^{n+1}}\sqrt{4xh_n(y)}\int_0^\infty J_n(z2\sqrt{2\tau})z^{n+1}e^{-z^2}z^1dz = k\sqrt{4xh_n(y)}r_1r_2(rp)x^{n-1}\tau^n2^{(n/2-1)}e^{-2\tau^2x^2} \quad .. \quad .. \quad (16)$$

The total cross-talk power in the r^{th} channel is

$$G^2(x) = \sum_1^\infty g_n^2(x) = \frac{4x}{\pi}(kr_1r_2rp\tau)^2e^{-4\tau^2x^2}\int_0^\infty \cos y\theta \sum_1^\infty\left(\frac{\sin\theta}{\theta}\right)^n\frac{(2\tau x)^{2n-2}}{n!}d\theta \quad (17)$$

on replacing $h_n(y)$ by its value as given by Equ. (11).

Summing, and taking the square root, we get for the total interference amplitude

$$G(x) = \sqrt{x}kr_1r_2(y\omega_N)e^{-2\tau^2x^2}\phi(\tau x)/2x$$

where

$$\phi(\tau x) = \left[\frac{4}{\pi}\int_0^\infty \cos y\theta\left\{\exp(4\tau^2x^2\sin\theta/\theta) - 1 - 4\tau^2x^2\sin\theta/\theta\right\}d\theta\right]^{\frac{1}{2}} \quad .. \quad (18)$$

Here, we have put $rp = \frac{r}{N}\cdot Np = y\omega_N$ where $\omega_N = Np$ is the angular frequency (video) corresponding to the top of the multi-channel band.

The integral in (18) cannot be evalulated in closed form, but very good approximations for the top and bottom of the band ($y = 1$ and 0) are found in Appendix 3. The variation (for the integral) is always less than $1:\sqrt{2}$ over the video band, and since the form is much simpler at the top, we will confine our attention there. However, it is seen from Equ. (18) that apart from this slow variation, $G(x)$ is also proportional to y, so that the interference *from the causes investigated*

in this example vanish at the bottom channels of the band.

Using the approximations of Appendix 3 for the top of the video band, we find the interference level in the top channel:

$$G(x)_{x=1} = G_1 \text{ (say)} \approx \sqrt{x} r_1 r_2 \omega_N \sqrt{1 - (1 + 4\tau^2 x^2) \exp(-4\tau^2 x^2)}\, 2x, \quad (\tau x < 1) \qquad (19)$$

For larger feeder lengths

$$G_1 \approx \sqrt{x} r_1 r_2 \omega_N \frac{1.175}{2x} \sqrt{\frac{1 - 0.32/(\tau x)^2}{\tau x}}, \quad \tau x > 1 \qquad (20)$$

For very short feeders, Equ. (19) gives

$$G_1 \approx \sqrt{2x} r_1 r_2 \omega_N \tau^2 x, \quad \tau x < 0.3 \qquad (21)$$

The actual curve as a function of τx is shown in Fig. 1.

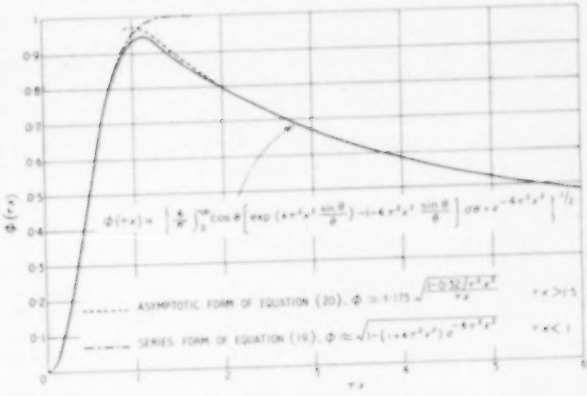
ASYMPTOTIC FORM OF EQUATION (20), $\Phi \approx 1.175 \sqrt{\frac{1-0.32/\tau^2x^2}{\tau x}}$, $\tau x > 1.5$
SERIES FORM OF EQUATION (19), $\Phi \approx \sqrt{1-(1+4\tau^2x^2)e^{-4\tau^2x^2}}$, $\tau x < 1$
$\Phi(\tau x)$
τx

Fig. 1. *Interchannel interference produced in a mis-matched feeder.*

For $\tau x = 1$, the ratio of 3rd to 2nd harmonic, when each in turn is arranged to occur at the top of the band, is $J_3(2\sqrt{2})/J_2(2\sqrt{2}) = 0.28/0.48 = 0.56$, so that the second harmonic can no longer be considered dominant. For values of τx greater than 1; $J_2(2\sqrt{2}\tau x)$ decreases, passing through zero when $\tau x = 1.8$, while the third, and subsequently the fourth and higher harmonics 'take over'. The interference decreases monotonically for values of τx greater than 1, and there is no simple direct relation between it and the various harmonics, apart from the already mentioned approximate equality to the second harmonic, when the latter is the dominant one.

It should be emphasized again that the behaviour described above is an *average* one, averaged for different values of the normally indeterminate phase angle $2\omega_c\tau - \theta_1 - \theta_2$. For a particular set-up, this quantity may, for example, be a multiple of π, so that

$$\sin(2\omega_c\tau - \theta_1 - \theta_2) = 0.$$

In this case there would be no second harmonic at all—and the interference would be correspondingly reduced—but such an example would not adequately describe the characteristics of the unit, since the next one might well have a large second harmonic—and interference level—consequent on a different value of the phase. The only way to obtain significant results is, as mentioned previously, to conduct the test over a range of values of phase (by varying ω_c or l) and to take the average of the results. This should then lead to the *average* harmonic levels and interference levels of Equs. (15) and (19) respectively.

As an example, consider a feeder 55ft long, with a system in which the r.m.s. frequency deviation is 2 Mc/s. Assume the r.f. feeder is a waveguide in which the group velocity of the waves is 0.7 light velocity. Then $\tau x = 2\pi \times 55 \times 12 \times 2.54 \times 2 \times 10^6 \times 1/(0.7 \times 3 \times 10^{10}) = 1$. This is at the transition between Equs. (19) and (20) for which the two functions of τx at $\tau x = 1$ are respectively 0.95 and 0.97. The correct value, used in obtaining Fig. 1, is 0.925 from the series expansion. It follows that, for this example, we can use the asymptotic form of Equ. (20) for runs longer than about 60ft, the interference amplitude for such lengths dropping roughly as the inverse square root of the feeder length.

If ω_N is 0.8 Mc/s and r_1 and r_2 correspond to standing-wave ratios of 0.95 and 0.8, we get, neglecting attenuation ($k = 1$).

$$G = \sqrt{\frac{1}{4}} \times \frac{1-0.95}{1+0.95} \times \frac{1-0.8}{1+0.8} \times \frac{0.8}{4} \times 0.925 = 0.263 \times 10^{-3},$$

Thus the interference is about 72-db down. This is some 7-db better than that obtained from Equ. (3) of Reference 2, from a consideration of the 2nd harmonic only.

9. Recommended Test Procedure

In order to estimate the interference level in the r^{th} channel, of video frequency rp, the following procedure is suggested:

(1) Inject a signal of frequency $rp/2$ and r.m.s. amplitude z, and measure the level of harmonic appearing in the r^{th} channel relative to the signal appearing in channel $(r/2)$. Vary z from zero to as large a value as the experiment may permit. Then the relative harmonic amplitude is $f_2(z)$ as defined in Equ. (2).

(2) Calculate $g_2(x)$ from $f_2(z)$ by means of Equ. (4). In this derivation the r.m.s. level at which it is intended to work the total video signal in the link is presumed known. x may usually be taken as 1/4. The integration may either be performed graphically or by fitting $f_2(z)$ with a polynomial $b_1z^2 + b_2z^3 + b_3z^5 + \ldots$ From Equ. (5) the value of $g_2(x)$ is $\sqrt{4x(1-y/2)}\,[b_1x + 3b_2x^3 + 12b_3x^5 + \ldots]$

(3) Repeat (1) but use a fundamental of frequency $rp/3$. The signal appears in channel $(r/3)$ and its third harmonic in channel r. The ratio of the amplitudes is $f_3(z)$.

(4) Derive $g_3(x)$ from $f_3(z)$ using Equ. (7). If $f_3(z)$ is fitted by $b_2z^2 + b_4z^4 + b_6z^6 + \ldots$ then, from Equ (8)

$$g_3(x) = \sqrt{4x(1 - y^2/3)/2}\,[3b_2x^2 + 12b_4x^4 + 60b_6x^6 + \ldots]$$

(5) Repeat the above measurements for the higher harmonics using a fundamental of frequency rp/n and deduce $g_n(x)$ from $f_n(z)$ by Equ. (11).

(6) The total interchannel interference power level G^2 is given by

$$G^2 = g_2^2(x) + g_3^2(x) + g_4^2(x) + \ldots$$

As explained in Section (7) it may be necessary to make a partial separation of the odd harmonics, to allow for the 'in-phase' effect.

(7) Repeat the above steps with slightly different carrier frequencies or feeder lengths, to simulate the effects of repeater variations.

If it can be shown that only the second and third harmonics are significant, then it is permissible to avoid most of the above analysis, and use simply Equs. (6) and (9) which give

$$\left.\begin{aligned} g_2(x) &\approx \sqrt{4x(1 - y/2)}\,.\,f_2(x) \quad \ldots \quad \ldots \\ g_3(x) &\approx \frac{3}{\sqrt{2}}\sqrt{4x(1 - y^2/3)}\,.\,f_3(x) \quad \ldots \\ G^2 &\approx g_2^2(x) + g_3^2(x) \end{aligned}\right\} \quad (22)$$

The measurement of $f_2(x)$ and $f_3(x)$ over a range of values of r.m.s. amplitude is not necessary here, and only the actual amplitude which it is intended to use in the working link is needed.

In deciding whether or not the second and third harmonics are the only ones of value, absolute smallness of these is not in itself a reliable criterion, although it may often be correct. For example, in the application given in Section 7, the second harmonic could be small either on account of the feeder phase being nearly a multiple of π, or because the length of feeder was actually such as to bring x_7 of Equ. (15) into the region giving low second harmonic, the third or higher harmonics being dominant. In the first case the smallness could be reflected in a low value of interference, albeit this effect would not be repeatable from repeater to repeater on account of the feeder phase angle not being exactly determinate. In the second case the small value of second harmonic could be misleading. If we had $\tau x = 1.8$ and $2\omega_c\tau - \theta_1 - \theta_2 = n\pi + \pi/2$, both second and third harmonic would be zero, although the interference in this case would be near its maximum. On the other hand, if kr_1r_2 were very small (feeder well matched) the second and third harmonics would be small and this would be 'genuine' in that the interference would be correspondingly small. Caution is therefore necessary before accepting low values of second and third harmonics at their face value.

10. Alternative Test Procedure

Since the bottom channel may, in practice, start somewhere around $r = 15$ instead of $r = 0$, it is not possible to carry out the above analysis too far, or over the whole of the band, as either the fundamental or its harmonics may be outside the range of the apparatus at one end of the band or the other. Hence an alternative method is in use in which a double-tone signal is injected and difference frequencies are looked for. This method has the advantage of being usable over the whole band. So long as only the second and third harmonics (of the single-tone test) are significant, the two methods give the same results, and the order of approximation is the same as that which leads to Equ. (22) above.

However, if higher-order harmonics than the third cannot be neglected, it is easy to see that the beat-frequency method no longer gives the various harmonics accurately, any more than $f_2(x)$ can give $g_2(x)$ directly ,as in the approximations of Equ. (22). The order of errors is probably the same in both cases, so that it is pointless to try to use the preceding analysis without the use of the correct functions $f_n(x)$ [except, as already stated, to the approximation of Equ. (22)]. There is, of course, a relation between the harmonic amplitudes $f_n(x)$ on the one hand, and the beat-frequency measurements on the other, but they certainly are not of any simple form. It is hoped to investigate this at a later date. Meanwhile, if the full analysis of this paper is

called for in any particular arrangement, there seems to be no alternative to the full procedure of Section (9) with its necessary limitations.

11. Conclusions

Although the general validity of existing test practice is confirmed in the case in which the second and third harmonics can be shown to be the only significant ones, caution is necessary in accepting low absolute values of these harmonics at their face value, especially when long feeder runs are involved. The complex analysis and harmonic method of testing outlined here seem to be essential when the higher harmonics are not negligible.

Further work will be required to bring out the relation between single tone and double tone methods of test.

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APPENDIX 1

Harmonic Generation.

Let the output for an input signal s be given by $V = a_1 s + a_2 s^2 + a_3 s^3 + \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1.1)$

$a_1 s$ will be taken to be the recovered signal. This means that the terms of fundamental frequency produced by the higher powers of s are negligible; i.e., that $a_1 \gg a_r$. (This will certainly be so in the case of low distortion, which is the case of interest here).

Let $s = x\sqrt{2}\cos\theta$ where x is the r.m.s. amplitude.

Now $\cos^n\theta = \frac{1}{2^{n-1}}\left[\cos n\theta + {}^nC_1 \cos\overline{n-2}\theta + {}^nC_2 \cos\overline{n-4}\theta + \ldots\right] \quad \ldots \quad \ldots \quad \ldots \quad (1.2)$

Substituting in (1) and picking out the various terms, we get (neglecting all $\cos\theta$ terms except $a_1\cos\theta$)

$$V = [x\sqrt{2}a_1]\cos\theta + \\ + [2x^2a_2{}^2C_0 \cdot 1/2 + (2x^2)^2 a_4{}^4C_1 \cdot 1/8 + (2x^2)^3 a_6{}^6C_2 \cdot 1/32 + \ldots]\cos 2\theta \\ + [(x\sqrt{2})^3 a_3{}^3C_0 \cdot 1/4 + (x\sqrt{2})^5 a_5{}^5C_1 \cdot 1/16 + (x\sqrt{2})^7 a_7{}^7C_2 \cdot 1/64 + \ldots]\cos 3\theta + \ldots \text{ etc.}$$

If we put $f_n(x)$ = ratio of n^{th} harmonic to fundamental, we get

$$\left.\begin{aligned} f_2(x) &= \frac{x}{\sqrt{2}a_1}\sum_1^\infty \frac{2n\,!}{2^{n-1}n-1\,!\,n+1\,!}a_{2n}x^{2n-2} \\ f_3(x) &= \frac{x^2}{2a_1}\sum_1^\infty \frac{2n+1\,!}{2^{n-1}n-1\,!\,n+2\,!}a_{2n+1}x^{2n-2} \\ f_4(x) &= \frac{x^3}{2\sqrt{2}a_1}\sum_1^\infty \frac{2n+2\,!}{2^{n-1}n-1\,!\,n+3\,!}a_{2n+2}x^{2n-2} \text{ etc.} \end{aligned}\right\} \quad (1.3)$$

These formulae, which are relations between amplitudes, are obviously not affected if the term $a_1 x\sqrt{2}\cos\theta$ is replaced by $a_1 x\sqrt{2}\cos(\theta + \alpha)$, so that the phase of the recovered signal is of no importance here.

APPENDIX 2

Generation of Interchannel Interference.

Let us consider a multi-channel signal of N channels, N being large. If ϵ_n represents a factor which is 1 or 0 according to whether the n^{th} channel is working or not, we get the form

$$S = x\sqrt{2/\text{N}}\sum_1^N \epsilon_n \cos(npt + \theta_n) \\ = x\sqrt{2/\text{N}}\,.\,z, \text{ say} \quad \ldots \quad \ldots \quad \ldots \quad (2.1)$$

Here, $\sum_1^N \epsilon_n{}^2 = \sum_1^N \epsilon_n = \text{N}N$. As explained in the text, N will be about a quarter, and the r.m.s. of S is x.

If a power series of S is under consideration, we need to handle such terms as

$$z^n = \left(\sum_1^N \epsilon_r \cos\phi_r\right)^n = \underbrace{\sum_1^N\sum_1^N \ldots \sum_1^N}_{n \text{ times}} \epsilon \cos\varphi_a \,.\, \cos\phi_b \ldots \cos\phi_n$$

where $\epsilon = \epsilon_a\epsilon_b \ldots \epsilon_n$ and $\phi_r = rpt + \theta_r$

If the product of cosines is replaced by sum and difference terms, it is seen that there can be all possible combinations of the form $\cos(\pm\phi_a \pm \phi_b \pm \ldots \pm\phi_n)$. Many of these terms will be repetitions of each other, and when like terms are collected together it is found that

$$z^n = \left(\sum_1^N \epsilon_r \cos\phi_r\right)^n = \\ 2^{1-n}\underbrace{\sum_1^N\sum_1^N \ldots \sum_1^N}_{n \text{ times}} \epsilon\,[\cos(\Sigma_m\phi_r) + {}^nC_1\cos(\Sigma_{m-1}\phi_r) + {}^nC_2\cos(\Sigma_{m-2}\phi_r) + \ldots] \quad (2.2)$$

The series stops at the centre term of the binomial coefficients.

$\Sigma_{m-n}\phi_r$ means $(\phi_a + \phi_b + \ldots) - (\phi_a + \phi_b + \ldots)$ with m positive angles and m negative angles, with $n-m$ positive angles and n negative angles, $a, b, \ldots, \alpha, \beta, \ldots$ being the suffixes which are each summed from 1 to N. The coefficients may be obtained by comparison with Equ. (1.2) to which Equ. (2.2) must reduce when either ϕ_r are all equal, or $N = 1$. The restriction of N to large values does not yet apply.

To what extent are terms in z^n repeated in z^m when m is greater than n? Obviously, m and n must be either both even or both odd, otherwise no term can be the same. Let us take them both even, and write $2n$ and $2m$ as the indices.

To get the r^{th} term of z^{2n} from z^{2m} we need to choose $2n - r + 1$ specific positive angles and $r - 1$ specific negative angles from a total of $2m$ angles, the rest of the $2m$ angles cancelling out in identical pairs of positive and negative angles. The term in z^{2m} which has the requisite form, namely $2n - r + 1 + \frac{1}{2}(2m - 2n) = m + n - r + 1$ positive angles, has a coefficient ${}^{2m}C_{m+n-r+1}$. Provided N is large enough, the choice of angles can be made in ${}^{m+n-r+1}C_{2n-r+1} \times {}^{m+n-r-1}C_{r-1}$ ways, with the choice of $m-n$ self-cancelling pairs in $(m-n)\,!$ ways. Hence the form of the r^{th} term of z^{2n} is repeated in z^{2m} in ${}^{2m}C_{m+n-r+1} \times {}^{m+n-r+1}C_{2n-r+1} \times {}^{m+n-r-1}C_{r-1} \times (m-n)\,!$ different ways. This factor simplifies to ${}^{2m}C_{r-1}\,{}^{2m-r}C_{m-n}\,(m+n)\,!\,2n\,!$ of which ${}^{2m}C_{r-1}$ is the same as the coefficient of the r^{th} term of z^{2n}. The summation over the $m-n$ self-cancelling pairs produces a further factor $\underbrace{\sum_1^N \ldots \sum_1^N}_{m-n \text{ times}} \epsilon_a{}^2\epsilon_b{}^2 \ldots = (\text{N}N)^{m-n}$, while from Equ (2.2) the expansions of z^{2n} and z^{2m} are seen to differ by an initial factor $2^{-(2m-2n)}$. Hence the entire z^{2n} is produced within z^{2m} with a factor $(\text{N}N/4)^{m-n}\,{}^{2m}C_{m-n}$ appears an additional factor $(x\sqrt{2/\text{N}N})^{2m-2n}$, giving an over-all factor $[x/\sqrt{2}]^{2m-2n}\,[{}^{2m}C_{m-n}\,(m+n)\,!/2n\,!]$.

The 'multiplicity factor' in square brackets can also be obtained as follows. z^{2m} is the product of $2m$ factors s, of which any $2n$ can produce z^{2n}, while the constant term

in the remaining z^{2n-2s} will provide, with the factor z^{2s}, some multiple of z^{2n}. The choice of $2s$ factors can be made in ${}^{2n}C_{2s}$ ways, while the constant term in z^{2n-2s} is seen, from Eqs. (2.2) to be $^{2n-2s}C_{n-s} \cdot 2^{1-2n-2s}$ times the number of ways of extracting $n-s$ self-cancelling pairs from $2n-2s$ suffixes, each running from 1 to N. This latter factor is $n-s\,!(2N)^{n-s}$. Since ${}^{2n}C_{2s} \cdot {}^{2n-2s}C_{n-s} \cdot n-s\,! = {}^{2n}C_{n-s} \cdot (n+s)\,!/2n\,!$ we have the same "multiplicity factor" as before. (In counting the number of self-cancelling pairs, such forms as $+a-a$ and $-a+a$ have been counted once only. The duplicity thereby omitted is made up for by the fact that the last term of the binomial coefficients appearing in Eqs. (2.2) should carry a factor $1/2$ when n is even).

Of the two derivations, the first has the advantage, however, of being "exclusive" in the sense that it shows that no further terms in ϵ^n occur in ϵ^{2n}, so that the groups of terms are now incoherent and add up power-wise.

Collecting all the terms associated with S^{2n}, we find that we have ϵ^{2n} multiplied by

$$2^{1-2n}(x\sqrt{2/N})^{2n}\left[\sum_{1}^{n} a_{2s+2n-2}\,\frac{z^{2n-2}}{2^{s-1}}\,\frac{(2n+2m-2)\,!}{(m-1)\,!\,(2n+m-1)\,!} \times \frac{(2n+m-1)\,!}{2n\,!}\right], \quad (2.3)$$

If this form is compared to the function $f_{2n}(x)$ of Equ. (1.3), they are seen to be very similar, the main difference being the occurrence in Equ. (2.3) of the factor $(2n+m-1)\,!/2n\,!$ multiplying the coefficient of $z^{2n-2m-2}$. Now $z^{2n+2m-2}(m+2n-1)\,!/2n\,! = (z^{2n+2m-2}/2n\,!)$

$$\int_0^\infty e^{-t}t^{2m+2n-1}dt$$

$$= (1/2n\,!)\int_0^\infty e^{-t}(xt)^{2n-2m-2}t^m dt$$

$$= (2x^{2n-2m-2}/2n\,!)\int_0^\infty e^{-t^2}t^{t^2}\cdot\,.\,.\,t^{2n+2m-2}\cdot\,.\,.\,t^{2n+1}dt$$

on putting $t = z^2/x^2$.

Using this result, the expression in Equ. (2.3) can be written

$$\frac{2n_1}{2n\,!}\,\frac{\sqrt{2}}{x^{2n-2}}\,\frac{1}{(xN)^n}\int_0^\infty e^{-z^2}z^{2n}f_{2n}(z)z^{2n+2}dz \quad . \quad . \quad (2.4)$$

The extra power of z and the factor $a_1\sqrt{2}$ appear because $f_{2n}(z)$, which is a relative amplitude had been obtained by dividing by $a_1\sqrt{2}z$ in Equ. (1.3), and this factor has had to be restored in Equ. (2.4).

In order to find the relative amplitude level of the interference arising from the terms of the form S^{2n}, we need to know the amplitude of z^{2n}. Denoting by ${}^{2n}A_r$ the resultant r.m.s. amplitude of those terms in z^{2n} which fall in the r^{th} channel, and dividing Equ. (2.4) by $a_1\epsilon\sqrt{1/xN}$, (the r.m.s. level of a working channel), we have the total interference level in the r^{th} channel arising from S^{2n} terms. Denoting this level by $g_{2n}(x)$ we find

$$g_{2n}(x) = \frac{2\sqrt{2x}}{2n\,!}\left[\frac{{}^{2n}A_r}{x^{2n}N^{n+1}}\right]\frac{1}{\epsilon^{2n+2}}\int_0^\infty f_{2n}(z)e^{-z^2}z^{2n}z^{2n+2}dz \quad (2.5)$$

A similar relation is found when the power of S is odd, so that, writing n for $2n$ in Equ. (2.5), we have the general relation for all n

$$g_n(x) = \frac{2\sqrt{2x}}{n\,!}\left[\frac{{}^{n}A_r}{x^{n}N^{n-1}}\right]\frac{1}{\epsilon^{n+2}}\int_0^\infty f_n(z)e^{-z^2}z^{n}dz \quad . \quad . \quad (2.6)$$

There remains the calculation of ${}^nA_r$. In ϵ^n, the term with $n-m$ positive angles and m negative angles has a coefficient ${}^nC_m$. There are $n-m\,!$ combinations of positive angles and $m\,!$ combinations of negative angles each giving the same term when the suffixes are summed. Hence, if there are α_m combinations of suffixes giving a resultant in the r^{th} channel, only $\alpha_m/[m\,!\,.\,n-m\,!]$ of them are independent and form an incoherent group. The mean-square amplitude is therefore $\frac{1}{2}\,{}^nC_m m\,!\,n-m)!^2\,\alpha_m/[m\,!\,n-m\,!]$, the factor $1/2$ arising as the mean square of a cosine term. This expression simplifies to $n\,!\,{}^nC_m\alpha_m/2$. The total mean square amplitude is thus $(n\,!/2)[\alpha_0 + {}^nC_1\alpha_1 + {}^nC_2\alpha_2 + \,.\,.\,.\,]$ terminating at the centre term of the binomial series. Now α_m is the number of combinations of suffixes, $n-m$ positive and m negative, whose sum falls in the bands $+r$ and $-r$. This is the same as the number of $n-m$ positive and m negative suffixes, plus the number of m positive and $n-m$ negative suffixes whose sum falls in the band $-r$(or $+r$). This is easily seen to be the coefficient of x^{-r} in

$$\left(\sum_1^N x^s\right)^{n-m}\cdot\left(\sum_1^N x^{-s}\right)^{m} + \left(\sum_1^N x^s\right)^{m}\cdot\left(\sum_1^N x^{-s}\right)^{n-m}.$$

The amplitude sum therefore reduces to the coefficient of x^{-r} in $\frac{1}{2}\,(n\,!\sum_1^n {}^nC_m\left(\sum_1^N x^s\right)^{n-m}\cdot\left(\sum_1^N x^{-s}\right)^{m} =$

$$\frac{1}{2}\,(n\,!\left[\sum_1^N x^s + \sum_1^N x^{-s}\right]^n$$

Summing the G.P. we get

$$\frac{1}{2}\,(n\,!\left[\frac{1-x^{N+1}}{1-x} + \frac{1-x^{-N-1}}{1-x^{-1}}\right]^n =$$

$$\frac{1}{2}\,(n\,!\left[\frac{1-x^{N+1}}{1-x}\,(1+x^{-N})\right]^n$$

When N is large we can replace $N+1$ by N without much error, so that we can write

$$({}^nA_r)^2 \approx (x^n n\,!/2) \times \text{coefficient of } x^{-r} \text{ in } \left(\frac{x^{-N}-x^N}{1-x}\right)^n \quad (2.7)$$

The factor x^n arises from the effects of ϵ_n which have so far been neglected. x is actually the probability that any particular term is present, and with n independent terms occurring in the summations leading to $({}^nA_r)^2$ the factor x^n accordingly appears.

Taking the square root of Equ. (2.7) and expanding both numerator and denominator by the binomial theorem we get

$${}^nA_r = x^{2n}[(\tfrac{1}{2}\,n\,!) \times \text{coefficient of } x^{-r} \text{ in } (1-x)^{-n}(x^{-nN} - {}^nC_1x^{-(n-2)N} + {}^nC_2x^{-(n-4)N}\,.\,.\,.)]^{\frac{1}{2}}$$

If we assume that r is large enough for such products as $r(r+1)$ to be replaced by r^2, we get the following fairly simple form

$${}^nA_r \approx x^{2n}\left\{(n/2)[(nN-r)^{n-1} - {}^nC_1\left\{(n-2)N-r\right\}^{n-1} + {}^nC_2\left\{(n-4)N-r\right\}^{n-1}\,.\,.\,.\right\}^{\frac{1}{2}} \quad . \quad . \quad . \quad (2.8)$$

the terms stopping when the coefficient of N in any bracket is less than 1.

An alternative formulation is given by putting $\left(\frac{x^{-N}-x^N}{1-x}\right)^n \approx \left(\frac{x^N-x^{-N}}{x^1-x^{-1}}\right)^n$, writing $x = e^{i\theta}$, and finding the coefficient of $e^{-ir\theta}$ by Fourier analysis. This gives $({}^nA_r)^2 = \frac{x^n n\,!}{4\pi}\int_0^{2\pi} e^{ir\beta}\left(\frac{\sin N\beta}{\sin\beta/2}\right)^n d\beta$.

For N and r both large, and $y = r/N$ finite and less than 1, only the range near $\beta = 0$ and π is important in the integrand. Changing the variable from β to $\theta = N\beta$, the range for θ can be taken to ∞. With $\sin\beta/2 \approx \beta/2$ at the bottom of the range, this gives the asymptotic form, for large N

$$({}^nA_r)^2 \approx \frac{n\,!\;2^nN^{n-1}x^n}{2\pi}\int_0^\infty \cos y\theta(\sin(\theta)/\theta)^n d\theta \quad (2.9)$$

Equ. (2.9) leads to the same result as Equ. (2.8) with $r = yN$.

It should be pointed out that although terms of the form z^m have been extracted from terms of the form z^n for m greater than n, when z^m is itself considered, no allowance has been made for the extracted terms. To this extent the approximations are of the same order as those made by Brockbank and Wass, and discussed in the text in Section 6, namely, the neglect of low-order products. But this is permissible here, since z^m with the low-order products removed is incoherent with $z^n (m > n)$, and since the interference terms of different orders are here treated as incoherent groups, the error of re-including the low-order products in z^m is at most of order $1/N$, an order of approximation which has been used elsewhere, for example in Equ. (2.9). But the inclusion of the low-order products of z^m in z^n is essential on account of their coherence. (Thus if $a \gg b$, b^2 can be neglected in the incoherent form $a^2 + b^2$, but in the coherent form $(a + b)^2 = a^2 + 2ab + b^2$, the additional term $2ab$ is not necessarily negligible. Brockbank and Wass treat all the low-order products in the first way.)

To find the 'in-phase' component of the odd harmonics, we need only those terms of ${}^nA_r$, say ${}^nB_r$, which are formed with $(n + 1)/2$ positive and $(n - 1)/2$ negative terms. This gives

$$({}^nB_r)^2 = x^n\left({}^nC_{(n-1)/2}\{[(n-1)/2]!\,[(n+1)/2]!\}\right)^2$$
$$x_{(n-1)/2}\left(2\{[n-1)/2]!\,[(n+1)/2]!\}\right) =$$
$$x^n(n!/2)\,{}^nC_{(n-1)/2}\,x_{(n-1)/2} \quad \ldots \quad \ldots \quad (2.10)$$

$x_{(n-1)/2}$ is the coefficient of x^r in $\left(\sum_1^N x^s\right)^{(n+1)/2}\left(\sum_1^N x^{-s}\right)^{(n-1)/2}$.

Summing the G.P.'s and making the same approximations as before, for large N, we get

$x_{(n-1)/2} \approx$ coefficient of x^r in $\left(\frac{1-x^N}{1-x}\right)^{(n+1)/2}$
$\left(x^{-N}\frac{1-x^N}{1-x}\right)^{(n-1)/2}$
$=$ coefficient of x^r in $\left(\frac{1-x^N}{1-x}\right)^n x^{-N(n-1)/2}$
$=$ coefficient of x^r in $(1-x)^{-n}$
$[x^{-N(n-1)/2} - {}^nC_1 x^{-N(n-3)/2} + \ldots]$
$\simeq \frac{1}{(n-1)!}\{[\frac{1}{2}N(n-1)+r)^{n-1} - {}^nC_1$
$(\frac{1}{2}N(n-3)+r)^{n-1} + \ldots\}$

the series stopping at the term ${}^nC_{(n-1)/2}r^{n-1}$

$$\therefore {}^nB_r \approx x^n\{\tfrac{1}{2}n\,{}^nC_{(n-1)}[(\tfrac{1}{2}N(n-1)+r)^{n-1} -$$
$${}^nC_1(\tfrac{1}{2}N(n-3)+r)^{n-1} + \ldots\}^+$$
$$= x^n\{\tfrac{1}{2}n\,{}^nC_{(n-1)}2^{1-n}[Nn + (2r-N)]^{n-1} -$$
$${}^nC_1[N(n-2)+(2r-N)]^{n-1} + \ldots\}^+$$

Comparing with Equ. (2.8) we see that ${}^nB_r$ is obtained from ${}^nA_r$ by multiplying by $({}^nC_{(n-1)/2}2^{1-n})^2$ and replacing r by $N - 2r$ (or alternatively, replacing y by $1 - 2y$). Thus instead of $\bar{h}_3(y) = \frac{1}{4}(1 - y^2/3)$ in Equ. (10) of Section 5 we have

$$\bar{h}_3(y) = {}^3C_1\,2^{-2}\,.\,\tfrac{1}{3}[1 - (1-2y)^2/3] = (1 + 2y - 2y^2)/4$$

Similarly $\bar{h}_5(y) = {}^5C_2\,.\,2^{-4}[46 - 12(1-2y)^2 +$
$(6/5)(1-2y)^4]/(24)^2$
$= 2(11 + 12y - 6y^2 - 12y^3 + 6y^4)/(24)^2$ etc.

When the 'in-phase' components of interference $\bar{f}_{2n+1}(x)$ have to be treated separately, the above functions $\bar{h}_{2n+1}(y)$ are used instead of $h_{2n+1}(y)$ in Equ. (10) of Section 5. The difference functions $h_{2n+1}(y) - \bar{h}_{2n+1}(y)$ must still be used to form a modified $f_{2n+1}(x)$ when the power-wise components of the interference are summed.

APPENDIX 3

Approximation to $\phi(\nu x)$.

Let $F(y,\lambda) = \int_0^\infty \cos y\theta\,[e^{\lambda\sin\theta/\theta} - 1 - \lambda\sin\theta/\theta]\,d\theta$.
$(\lambda = 4\pi^2\nu x)$.

At the top and bottom of the video band, $y = 1$ and 0 respectively.

We define

$$F_0 = F(0,\lambda) = \int_0^\infty [e^{\lambda\sin\theta/\theta} - 1 - \lambda\sin\theta/\theta]\,d\theta \quad (3.1)$$

$$F_1 = F(1,\lambda) = \int_0^\infty \cos\theta\,[e^{\lambda\sin\theta/\theta} - 1 - \lambda\sin\theta/\theta]\,d\theta \quad (3.2)$$

Integrating by parts, we get

$$F_0 = \theta\,[e^{\lambda\sin\theta/\theta} - 1 - \lambda\sin\theta/\theta]_0^\infty -$$
$$\lambda\int_0^\infty \theta(\cos\theta/\theta - \sin\theta/\theta^2)\,[e^{\lambda\sin\theta/\theta} - 1]\,d\theta =$$
$$= \lambda\int_0^\infty \cos\theta\,[e^{\lambda\sin\theta/\theta} - 1]\,d\theta +$$
$$\lambda\int_0^{\pi/2} \frac{\sin\theta}{\theta}\,[e^{\lambda\sin\theta/\theta} - 1]\,d\theta$$
$$= -\lambda\int_0^\infty \cos\theta\,[e^{\lambda\sin\theta/\theta} - 1 - \lambda\sin\theta/\theta]\,d\theta -$$
$$\lambda^2\int_0^{\pi/2} \frac{\cos\theta\sin\theta}{\theta}\,d\theta +$$
$$+ \lambda\frac{\partial}{\partial\lambda}\int_0^\infty [e^{\lambda\sin\theta/\theta} - 1 - \lambda\sin\theta/\theta]\,d\theta$$
$$= -\lambda F_1 - \lambda^2\frac{\pi}{4} + \lambda\frac{\partial}{\partial\lambda}F_0$$
$$\therefore F_1 = \frac{\partial F_0}{\partial\lambda} - \frac{F_0}{\lambda} - \lambda\frac{\pi}{4} = \lambda\frac{\partial}{\partial\lambda}(F_0/\lambda) - \lambda\frac{\pi}{4} \quad (3.3)$$

This relation gives F_1 in a simple way when F_0 is found. To find F_0, expand Equ. (3.1) and integrate

$$F_0 = \sum_2^\infty \frac{\lambda^n}{n!}\int_0^{\pi/2} (\sin\theta/\theta)^n\,d\theta \quad \ldots \quad \ldots \quad \ldots \quad (3.4)$$

The following values are easily obtained (e.g., Whittaker and Watson, p. 123, example 13)—

$$\int_0^{\pi/2} (\sin\theta/\theta)^3\,d\theta = \frac{\pi}{2}\,.\int_0^{\pi/2} (\sin\theta/\theta)^5 d\theta =$$
$$\frac{\pi}{2}\,.\,\frac{3}{4}\,.\int_0^{\pi/2} (\sin\theta/\theta)^5 d\theta = \frac{\pi}{2}\,.\,\frac{3}{4}\,.\,\frac{5}{6}\,.$$
$$\int_0^{\pi/2} (\sin\theta/\theta)^5 d\theta = \frac{\pi}{2}\,.\,\frac{5}{8}\,.\left(\frac{23}{24}\right).\int_0^{\pi/2} (\sin\theta/\theta)^6 d\theta =$$
$$\frac{\pi}{2}\,.\,\frac{5}{16}\left(\frac{11}{12}\right).$$
$$\int_0^{\pi/2} (\sin\theta/\theta)^6 d\theta = \frac{\pi}{2}\,.\,\frac{5}{14}\left(\frac{151}{180}\right), \text{ etc.}$$

From this we get the approximation

$$\int_0^{\pi/2} (\sin\theta/\theta)^n d\theta \approx \frac{\pi}{2}\,\frac{n}{2(n-1)}$$

which is exact to $n = 4$, and still nearly correct at $n = 8$. Thus a good approximation in the neighbourhood of the origin is

$$F_0 \approx \frac{\pi}{4}\sum_2^\infty \frac{\lambda^n}{n!}\,\frac{n}{n-1} = (\pi/4)\lambda\sum_1^\infty \lambda^n/(n\,.\,n!) =$$
$$(\pi/4)\lambda\int_0^\lambda (e^\lambda - 1)/\lambda\,d\lambda$$

Jahnke and Emde define (page 2)

$$\overline{Ei}(x) = \log_e x + \int_0^x (e^t - 1)/t \, dt$$

Hence $F_0 \approx (\pi/4)\lambda\,[\overline{Ei}(\lambda) - \log_e \lambda]$ ($\log \gamma = 0.577$) (3.5)

The probable limit of validity of Equ. (3.5) is when the eighth term of the exponential series becomes significant, which is about $\lambda = 4$. Since $\lambda = 4\pi^2 s^2$ this gives $\pi s < 1$ as the upper limit.

From Equ. (3.3) $F_1 = \frac{\pi}{4}\lambda(e^\lambda - 1)/\lambda - \lambda\pi/4 =$

$$\frac{\pi}{4}(e^\lambda - 1 - \lambda) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3.6)$$

To get a form usable in the range $\lambda \gg 4$, we need an asymptotic form for $\int_0^\infty (\sin\theta/\theta)^n \, d\theta$ for large n. Now when n is large, only the range near $\theta = 0$ is of value in the integrand. The forms $e^{-n\theta^2/6}(1 - n\theta^4/180)$ and $(\sin\theta/\theta)^n$ are the same up to powers of θ^4, and can be shown to give

$$\int_0^\infty (\sin\theta/\theta)^n d\theta \approx \int_0^\infty e^{-n\theta^2/6}(1 - n\theta^4/180)\, d\theta =$$

$$\frac{\pi}{2}\sqrt{\frac{6}{\pi n}}\left(1 - \frac{15}{20n}\right) \approx \frac{\pi}{2}\sqrt{\frac{6}{\pi(n + 3/10)}}.$$

This last form is very good, even for so low a value as $n = 2$. However, it cannot be used directly as the resulting series cannot be easily handled.

Now $\int_0^{\frac{\pi}{2}} (\cos\theta)^r d\theta = \frac{1}{2}\frac{\Gamma\frac{1}{2}\Gamma(r+1)/2^{\frac{1}{2}}}{\Gamma(r+2)/2}$. The form taken when r is large is easily found by using the asymptotic form for the gamma functions. With r replaced by $n - 1/5$ we get

$$\int_0^{\frac{\pi}{2}} (\cos\theta)^{n-1.5} d\theta \approx \frac{\pi}{2}\sqrt{\frac{2}{\pi(n + 3/10)}}.$$

Hence $\int_0^\infty (\sin\theta/\theta)^n d\theta \approx \sqrt{3}\int_0^{\frac{\pi}{2}} (\cos\theta)^{n-1.5} d\theta$

Using this result, it is found that

$$F_0 \approx \sqrt{3}\int_0^{\frac{\pi}{2}} [e^{\lambda\cos^2\theta} - 1 - \lambda\cos\theta](\cos\theta)^{-1.5} d\theta \quad (3.7)$$

The first term of the expansion of Equ. (3.6), which is the correct one, is equal to the first term of the expansion of Equ. (3.7) within 10 per cent. The succeeding terms in Equ. (3.7) rapidly approach their correct values.

Equ. (3.7) could also have been obtained, albeit in a rather superficial manner (on account of the path of integration for ϕ), by the substitution $\sin\theta/\theta = \cos\phi$ directly in Equ. (3.1), and using series expansions of θ and $\cos\theta$ in terms of ϕ.

It remains to find the asymptotic form of Equ. (3.7). For large λ only the term $e^{\lambda\cos^2\theta}$ is important. Expanding to the first few powers of θ, we get

$$F_0 \approx \sqrt{3}\int_0^{\frac{\pi}{2}} e^{\lambda(1 - \theta^2/2 + \theta^4/24)}(1 + \theta^2/10) d\theta$$

$$\approx \sqrt{3}e^\lambda \int_0^{\frac{\pi}{2}} e^{-\lambda\theta^2/2}(1 + \theta^2/10 + \lambda\theta^4/24) d\theta$$

Putting $\phi = \lambda\theta^2/2$, and taking the upper limit of ϕ to ∞, we find

$$F_0 \approx e^\lambda\sqrt{3/(2\lambda)}\int_0^\infty e^{-\phi}\phi^{-\frac{1}{2}}(1 + \phi/(5\lambda) + \phi^2/(6\lambda))\, d\phi$$

$$= e^\lambda\sqrt{3\pi/(2\lambda)}\,[1 + 1/(10\lambda) + 1/(8\lambda)]$$

$$= e^\lambda\sqrt{3\pi/(2\lambda)}\,[1 + 9/(40\lambda)]$$

From Equ. (3.3) we find, for the asymptotic form of F_1

$$F_1 \approx e^\lambda\sqrt{3\pi/(2\lambda)}\,[1 - 1.275/\lambda]$$

This form is valid for values of λ greater than about 4 i.e., $\pi s > 1$.

REFERENCES

[1] Beckbank and Wass, "Non-linear Distortion in Transmitting Systems," *J. Instn elect. Engrs*, 1945, Vol. 92, Part III.

[2] L. Lewin, J. J. Muller and R. Bassard, "Phase Distortion in Feeders," *Wireless Engineer*, May 1950, Vol. 27, p. 143.

[3] G. N. Watson, "A Treatise on the Theory of Bessel Functions," (2nd Edition), Cambridge University Press, 1944, p. 394, Eqs. (4).

NEW BOOKS

Wireless Servicing Manual (8th edition)
By W. T. Cocking, M.I.E.E. Pp. 296 with 137 illustrations. Iliffe & Sons, Ltd., Dorset House, Stamford St., London, S.E.1. Price 12s. 6d.

Technical Instruction for Marine Radio Officers
(9th Edition) (formerly Handbook of Technical Instruction for Wireless Telegraphists).
By H. M. Dowsett, M.I.E.E., F.Inst.P. and L. E. Q. Walker, A.R.C.S. Pp. 690 with 731 illustrations. Iliffe & Sons, Ltd., Dorset House, Stamford St., London, S.E.1. Price 60s.

The Measurement of the Time Constant of a Critically Damped Meter
By S. F. Pearce, B.Sc., F.Inst.P. Technical Report M/T 107. Pp. 7. The British Electrical & Allied Industries Research Association, Thorncroft Manor, Dorking Rd., Leatherhead, Surrey. Price 3s.

Television
Vol. V, 1947-1948, pp. 461 + x; Vol. VI, 1949-1950, pp. 422 + x. (Reprints of articles by R.C.A. authors), R.C.A. Review, Radio Corporation of America, R.C.A. Laboratories Division, Princeton, N.J., U.S.A.

Calcul Opérationnel
By Édouard Labin. Pp. 149. (in French). Masson et Cie, 120 boulevard Saint-Germain, Paris 6e, France. Price Fr. 780.

Radio Control for Models
By G. Honnest-Redlich. Pp. 128. Harborough Publications, The Aerodrome, Billington Rd., Stanbridge, Nr. Leighton Buzzard, Beds. Price 8s. 6d.

Testing Radio Sets (5th Edition)
By J. H. Reyner. Pp. 215 + viii. Chapman & Hall Ltd., 37, Essex St., London, W.C.2. Price 22s. 6d.

Questions and Answers in Television Engineering
By Carter V. Robinoff and Magdalena E. Wolbrecht. Pp. 300 + vii. McGraw Hill Publishing Co. Ltd., Aldwych House, London, W.C.2. Price (in U.K.) 38s. 6d.

Electrical Communication (3rd Edition)
By Arthur L. Albert. Pp. 593 + ix. Chapman & Hall, 37, Essex St., London, W.C.2. Price (in U.K.) 52s.

Electric-Wave Filters (2nd Edition)
By F. Scowen. Pp. 188 + xi. Chapman & Hall Ltd., 37, Essex St., London, W.C.2. Price 18s.

Threshold Signals (M.I.T. Radiation Laboratory Series Vol. 24)
Edited by James L. Lawson and George E. Uhlenbeck. Pp. 388 + xii. McGraw Hill Publishing Co. Ltd., Aldwych House, London, W.C.2. Price (in U.K.) 42s. 6d.

ABSTRACTS and REFERENCES

Compiled by the Radio Research Board and published by arrangement with the Department of Scientific and Industrial Research

The abstracts are classified in accordance with the Universal Decimal Classification. They are arranged within broad subject sections in the order of the U.D.C. numbers, except that notices of book reviews are placed at the ends of the sections. U.D.C. numbers marked with a dagger (†) must be regarded as provisional. The abbreviations of the titles of journals are taken from the World List of Scientific Periodicals. Titles that do not appear in this List are abbreviated in a style conforming to it.

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FIRST GROUP

ACOUSTICS AND AUDIO FREQUENCIES

016 : 534 **2682**

References to Contemporary Papers on Acoustics.—A. Taber Jones. (*J. acoust. Soc. Amer.*, July 1950, Vol. 22, No. 4, pp. 522–528.) Continuation of 2395 of October.

534.231 **2683**

The Propagation of a Sound Pulse in the Presence of a Semi-Infinite Open-Ended Channel: Part 1.—W. Chester. (*Philos. Trans. A.*, 5th Sept. 1950, Vol. 242, No. 854, pp. 527–556.) Two problems are discussed. In the first, a sound pulse originates inside a duct between two semi-infinite parallel planes and travels to and beyond the open end, where it undergoes partial reflection. In the second case, the pulse originates outside the duct and approaches the open end from an arbitrary direction. A succession of diffracted waves is created at the end of the duct, for which in the first case a general formula is derived by operational methods. A simple reciprocity relation is applied to deduce the form of the wave in the duct in the second case. Ultimately the returning wave becomes sensibly plane and splits up into regions of length equal to the distance between the boundary planes, the form of the potential depending on the number of diffracted waves which contribute to each particular region. Explicit expressions are obtained for the potential in the first two regions at the head of the returning wave and for the third region when the pulse originates within the duct. The case of an initial velocity distribution given by the Heaviside unit pulse is treated in detail.

534.232 : 534.321.9 **2684**

The Relative Output from Magnetostriction Ultrasonic Generators.—F. M. Leslie. (*J. acoust. Soc. Amer.*, July 1950, Vol. 22, No. 4, pp. 418–421.) Equivalent transmission-line circuits are used to develop formulae for the resonance frequency and output of the simple bar oscillator and the dumbbell type. Approximations in the latter case do not introduce any great discrepancy between calculated and measured values of resonance frequency. The formulae, though applicable directly to the symmetrical dumbbell oscillator, may be easily applied to the asymmetrical oscillator and to those in which the face area is less than the cross-section of the neck.

534.232 : 534.321.9 : 621.3.087.6 **2685**

Application of Supersonic Energy to High-Speed Electronic Recording.—H. J. Dana & J. L. Van Meter. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 473–476.) See 1561 of July.

534.24 : 532.582.3 **2686**

Sound Scattering from a Fluid Sphere.—V. C. Anderson. (*J. acoust. Soc. Amer.*, July 1950, Vol. 22, No. 4, pp. 426–431.) A mathematical solution is obtained for scattering from a sphere of size comparable with the wavelength, with acoustic properties near to those of the surrounding medium. The reflectivity for direct backward scattering is presented as a function of relative density and relative sound velocity. Comparison is made with the Rayleigh limiting case and with the case of a fixed rigid sphere. For diameters comparable with the wavelength, scattering may show pronounced maxima and minima.

534.373 : 534.213.4 **2687**

Classical Viscosity in Tubes and Cavities of Large Dimensions.—B. P. Bogert. (*J. acoust. Soc. Amer.*, July 1950, Vol. 22, No. 4, pp. 432–437.) "A method for the calculation of viscous losses in acoustic wave guides and cavities is described, similar to that used by Carson, Mead, and Schelkunoff for electromagnetic waves. The loss in a plane wave in a round tube is discussed and the results agree with those previously obtained by others. The attenuation for two higher modes in hard-wall guides is computed, as well as the decay constants for a cylindrical cavity for longitudinal and pure radial modes."

534.414 **2688**

Acoustic Resonators of Circular Cross-Section and with Axial Symmetry.—A. K. Nielsen. (*Trans. Dan. Acad. tech. Sci.*, 1949, No. 10, 70 pp. In English.) The literature on this subject is critically reviewed. The usual approach to resonator theory is inadequate for two reasons. Firstly, the velocity distribution in the coupling aperture is usually assumed constant in order to satisfy boundary conditions. This assumption actually violates the boundary condition at the sharp edges of the coupling aperture, where the velocity becomes infinite (neglecting losses). Secondly, the interaction between the wave

emitted from the coupling aperture and that reflected from the cylindrical walls of the resonator has been neglected. An expression for the velocity distribution is derived which satisfies the rise-to-infinity condition at the edge of the aperture and a formal solution of the wave equation is obtained, assuming the velocity distribution in the aperture to be known. The results are used to calculate the resonance frequency of a symmetrical resonator by the energy method. Formulae are also given for symmetrical resonators. The end correction for a flanged organ pipe is found to be $0.8220\,r$, a slightly better approximation than Rayleigh's value of $0.8242\,r$. The effects of viscosity and heat conduction are also considered. Experimental results for various resonators and flanged organ pipes agree with the theoretical values to within 1%.

534.417 : 621.395.614 2689

Crystal Microphone for Underwater Sounds.—W. Güttner. (*Z. angew. Phys.*, May 1950, Vol. 2, No. 5, pp. 206–210.) The microphone consists of 10 Rochelle-salt plates with 45° X-cut, mounted between elastic supports so that the sound pressure acts only on the front membrane. Its response characteristic is shown; this is largely independent of temperature change. The method of calibration is described. The measured response of the receiver agrees well with values calculated from crystal data.

534.442 2690

Methods and Instruments for the Visual Analysis of Complex Audio Waveforms.—H. R. Foster & E. E. Crump. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 564–572.)

534.442.2 : 621.302.52 2691

A Continuously Variable Filter.—C. G. M. Fant. (*J. acoust. Soc. Amer.*, July 1950, Vol. 22, No. 4, pp. 449–453.) A heterodyne filter for the speech frequency range is described. Band-pass filtering with continuously variable low- and high-frequency cut-offs or band-elimination filtering with variable mid-frequency and fixed bandwidth are possible. Variable filtering is performed by s.s.b. transmission with successive filtering and demodulation. The filter was designed for speech investigations and wave analysis in the range 40–2 000 c/s.

534.75 : 534.782 2692

The Frequency Selectivity of the Ear as Determined by Masking Experiments.—T. H. Schafer, R. S. Gales, C. A. Shewmaker & P. O. Thompson. (*J. acoust. Soc. Amer.*, July 1950, Vol. 22, No. 4, pp. 490–496.)

534.78 : 621.314.26 2693

Devices for Speech Analysis and Compression.—F. Vilbig. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 573–581.)

534.833.4 2694

Acoustic Materials.—(*Tech. Bull. nat. Bur. Stand.*, July 1950, Vol. 34, No. 7, pp. 96–102.) A review of the essential theory of sound absorption, the principles governing the use of absorptive materials, the various types of such materials, their physical properties and methods of measurement.

534.846.6 2695

The Use of Three-Dimensional Models in Room Acoustics.—R. W. Muncey. (*J. acoust. Soc. Amer.*, July 1950, Vol. 22, No. 4, pp. 510–511.) The chief difficulty in the construction and use of models for investigation of room acoustics is the provision of bounding surfaces to simulate the properties of those of the full-size hall. Investigations of the use of small-scale models have been commenced at the Building Research Laboratory, Victoria, Australia.

621.3.018.787 : 621.317.79 2696

An Intermodulation Analyser for Audio Systems.—Fine. (*See* 2840.)

621.395.612.45 2697

New 'Unobtrusive' Ribbon Pressure Microphone.—H. F. Olson & J. Preston. (*Broadcast News*, May–June 1950, No. 59, pp. 24–28; *Audio Engng, N.Y.*, July 1950, Vol. 34, No. 7, pp. 18–20.) Theory and description of a microphone with uniform response from 50 c/s to 15 kc/s. A small pickup horn applies sound pressure to the ribbon through a cylindrical tube and tapered connector, the back of the ribbon being coupled to the damping labyrinth by a similar connector.

621.395.623.7 2698

Electroacoustic Phase Shift in Loudspeakers.—C. A. Ewaskio & O. K. Mawardi. (*J. acoust. Soc. Amer.*, July 1950, Vol. 22, No. 4, pp. 444–448.) The modulation phase-shift method of Nyquist & Brand was adapted for direct indication of envelope delay (the slope of the phase-shift curve) by using an electronic phase-meter. A continuous record was obtained of the delay for various loudspeakers by means of an automatic level recorder suitably connected to the phase-meter. The results, together with pressure-amplitude response curves, may serve as a basis for assessing the quality of a loudspeaker.

621.395.625.3 : 681.6 2699

Duplication of Magnetic Tape Recordings by Contact Printing.—Herr. (*See* 2804.)

621.395.625.3 : 681.6 2700

A New Magnetic Record Duplicating Process.—Camras. (*See* 2803.)

681.85 2701

A Variable Speed Turntable and its Use in the Calibration of Disk Reproducing Pickups.—H. E. Haynes & H. E. Roys. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 556–563.) See 1578 of July.

681.85 : 534.862.4 2702

The Diamond as a Phonograph Stylus Material.—E. J. Marcus & M. V. Marcus. (*Audio Engng, N.Y.*, July 1950, Vol. 34, No. 7, pp. 25–27, 41.) The properties of natural diamonds, which make them pre-eminent for use as stylus points, are described and a photographic comparison is made of the normal wear of commonly used stylus materials, showing the very great superiority of the diamond. Natural small stones, owing to their greater structural strength, are better than chips cut from larger gem stones. A short account is given of the occurrence of the stones and of the methods of preparing them for use.

534.321.9 : (5 + 6 2703

Der Ultraschall und seine Anwendung in Wissenschaft und Technik. (Ultrasonics and its Application in Science and Technology) [Book Review]—L. Bergmann. Publishers: S. Hirzel Verlag, Zürich, 5th edn 1949, 748 pp., 50 Swiss fr. (*J. acoust. Soc. Amer.*, July 1950, Vol. 22, No. 4, p. 517.) "The author has rendered a genuine service to all workers in ultrasonics and allied fields by bringing together so much valuable material in one place and organizing it so systematically and efficiently. No worker in the field can really afford to have this book very far away from his desk." Over 2 300 references are included. The 3rd edition was noted in 280 of 1946.

534.833.4 2704

Sound-Absorbing Materials. [Book Review]—C. Zwikker & C. W. Kosten. Publishers: Elsevier Publishing Co., Amsterdam, Brussels & New York.

Cleaver-Hume Press, London, 1949, 174 pp., $3.00 or 22s. 6d. (*Research, Lond.*, June 1950, Vol. 3, No. 6, pp. 281–282.) "A highly scientific study of the physical behaviour of sound waves impinging on and penetrating into absorbent constructions of any type."

2708

534.84

Acoustical Designing in Architecture. [Book Review]—V. O. Knudsen & C. M. Harris. Publishers: J. Wiley & Sons, New York, 1950, 404 pp., $7.50. (*Proc. Inst. Radio Engrs*, July 1950, Vol. 38, No. 7, p. 842.) A nonmathematical presentation. A little space is devoted to discussion of sound-amplification systems and studio design. Tables of sound-absorption coefficients and sound-insulation data are brought together in the appendices.

AERIALS AND TRANSMISSION LINES

2706

621.392.26†

Some Properties of Waveguides with Periodic Structure.—A. W. Lines, G. R. Nicoll & A. M. Woodward. (*Proc. Instn elect. Engrs*, Part III, July 1950, Vol. 97, No. 48, pp. 263–270.) A general description of the frequency characteristics of waveguides with periodic structure is derived from a discussion of loaded transmission lines. Analysis of an equivalent circuit is used to give a detailed confirmation of these characteristics. The periodic guide with systematically detuned resonators is then examined by these methods, all the general features being obtained by elementary reasoning. A more detailed treatment, based on Maxwell's equations, is required for specific design problems and this is used in the design of a periodic waveguide with every third resonator detuned, for which a space harmonic exists with constant phase velocity over a wide frequency band. Possible experimental techniques for checking the theoretical frequency characteristics are discussed and the results obtained by one technique for the constant-phase-velocity guide are given.

2707

621.392.26† : 621.3.09

Electromagnetic Waves in Circular Wave-Guides containing Two Coaxial Media.—R. D. Teasdale & H. J. Higgins. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 427–441.) The general problem is treated in detail. A conditional equation governing propagation in such waveguides is derived. The two conditions for which simple E or H waves can be propagated are determined and discussed. Curves relating phase velocity to design parameters are plotted for the E_0 wave and examples are discussed for which the general solution reduces to particular solutions given by other authors.

2708

621.392.26† : 621.3.09

On the Theory of Electromagnetic Radiation in Metal Tubes.—R. Honerjäger. (*Z. Phys.*, 20th June 1950, Vol. 128, No. 1, pp. 72–78.) The radiation field of an electric and magnetic dipole of given moment in an infinitely long straight metal tube of arbitrary cross-section is calculated for E and H waves, and also the total e.m. power flux through the tube.

2709

621.396.67 + 621.396.611.1

A Combination Slot Antenna and Resonant Tank Circuit.—N. L. Harvey. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 183–189.) An impedance transforming and coupling network is usually required between the transmitter unit and the aerial. The coupling network can be eliminated by using the edges of the aerial slot as the resonant circuit of the transmitter unit. Such an arrangement is especially suitable for wide-band applications.

2710

621.396.67

Impedance and Radiation Characteristics of Slotted-Cylinder Antennas.—R. E. Beam & H. D. Ross, Jr. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 172–182.) Approximate theoretical expressions are developed for the input impedance and radiation patterns of a slotted-cylinder aerial with a narrow slot of length equal to or greater than the free-space half wavelength, and fed at the midpoint of the slot. The aerial is considered as a slot-loaded cylindrical waveguide in calculating the cut-off frequency and phase constant along the slot. Babinet's principle is applied to the determination of the radiation resistance. Experimental results are in good agreement with theory.

2711

621.396.67

Slot Radiators.—N. A. Begovich. (*Proc. Inst. Radio Engrs*, July 1950, Vol. 38, No. 7, pp. 803–806.) By an extension of Babinet's principle Booker has shown (1335 of 1947) that the field pattern of a slot aerial is identical with that of the corresponding wire aerial, but with the electric and magnetic fields interchanged. A rigorous proof of this is now given, using the double-current-sheet diffraction formula. Integration of Poynting's vector over both surfaces of the slot gives a driving impedance of $362.5 + j210.5$. The real part of this is in excellent agreement with experimental measurements. The mutual impedance between slots, which must be known for array calculations, is also determined.

2712

621.396.67

The Slot Radiator, a Magnetic Dipole for Centimetre Waves.—H. Severin. (*Z. Phys.*, 20th June 1950, Vol. 128, No. 1, pp. 108–119.) The slot radiator is represented as a magnetic dipole and its mode of operation by the theory of diffraction of e.m. waves at a small aperture in a perfectly conducting screen. Measured values of the radiation from and magnetic moment of small elliptical-slot radiators disposed respectively parallel and perpendicular to the magnetic field of the incident wave are in good agreement with calculations, provided the linear dimensions of the apertures are $< \lambda/3$.

2713

621.396.67

Correction of Spherical Aberration by a Phased Line Source.—R. C. Spencer, C. J. Sletten & J. E. Walsh. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 320–333.) Theory of the spherical reflector with corrected line source is developed. Tests using feeds such as open waveguides, horns, polyrod, slotted and dipole line sources show that if the phasing is suitably adjusted, aberrationless scanning of a pencil beam over at least $\pm 30°$ in any direction can be achieved.

2714

621.396.67

The Electromagnetic Field in the Vicinity of a Linear Conductor.—P. H. Nelson. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol 5, pp. 315–319.) A study is made of the interference pattern in the vicinity of a linear conductor, of infinite length and zero resistance, subjected to the action of a plane e.m. wave with electric-field vector parallel to the conductor. The reradiated field is independent of the incident field except at the surface of the conductor, so that superposition of the incident and radiated fields gives the interference pattern required. Experiments at a frequency of 3000 Mc/s with some simple types of conductor gave results in close agreement with theoretical calculations.

2715

621.396.67

End-Loaded and Expanding Helices as Broad-Band Circularly Polarized Radiators.—P. W. Springer. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 161–171.) The simplicity of the axial-mode helix makes

is particularly suitable for the radiation of circularly polarized waves, but *for applications requiring* either modified radiation patterns or broad transmission bands it is often necessary to modify the simple helix. Two types, the short end-loaded helix and the expanding helix, are of particular value where extreme bandwidths are required. The theory of operation, impedance curves, polar diagrams, current and phase distribution, are discussed and arrays are described providing (*a*) broad azimuth coverage, (*b*) sharp radiation patterns.

621.396.67 2716

Antifading Broadcast Antenna.—H. Brueckmann. (*Electronics*, Aug. 1950, Vol. 23, No. 8, p. 228.) Correction to article abstracted in 1863 of August.

621.396.67 : 621.317.79 2717

The Electronically Driven Ripple-Tank as an Aid to Phase-Front Visualization.—Schooley. (*See* 2841.)

621.396.67 : 621.392.26† 2718

The Channel-Guide Antenna.—W. Rotman. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 190–202.) The general condition for radiation from the slot of a channel-guide aerial is derived in terms of the near-field distribution of e.m. energy, which may be described as a form of single-mode transmission in the supporting waveguide, characterized by a complex propagation constant. A method of computing the propagation constant gives results for different channel geometries which are in agreement with experiment. Practical methods of coupling channel-guide aerials to microwave sources are considered.

621.396.67 : 621.397.62 2719

An Automatic Built-In Antenna for Television Receivers.—K. Schlesinger. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol 5, pp. 292–302.) See 819 of April.

621.396.67.012 2720

A Graphical Analysis of the Interference Patterns of an Elevated Ultra-High-Frequency Antenna under Conditions of Atmospheric Stratification.—F. R. Abbott & C. J. Fisher. (*J. appl. Phys.*, July 1950, Vol. 21, No. 7, pp. 636–641.)

621.396.67.029.64 : 535.42 2721

Small-Surface Microwave Diffraction.—A. Applebaum & P. C. Fritsch. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 442–449.) The diffraction of plane-polarized e.m. waves by reflection from small perfectly conducting surfaces (diameter of the order of λ) is calculated for any angle of incidence by Schelkunoff's "current-sheet" method. A correction for boundary effects is determined. Experimental results obtained with an unmodulated reflex klystron, Type 2K39, as the power source, are in good agreement with theory.

621.396.673 : 621.397.61 2722

1 057-Foot FM-TV Antenna.—(*Broadcast News*, May/June 1950, No. 59, pp. 8–15.) Situated at Atlanta, U.S.A., a 1 000-ft tower supports an R.C.A. Supergain television aerial (1865 of August). Above this is a f.m. aerial, a 4-section pylon, R.C.A. Type BF-14D. The television aerial has a gain of 11.5, which, with a 5-kW transmitter, gives an effective radiated power of 52 kW. The f.m. aerial has a power gain of 6; provision is made for an additional four sections to double this gain. The earthing system consists of radial copper straps 50 ft long spaced every five degrees, buried 6 in. deep and terminating in copper earthing rods.

621.396.677 2723

A Wide-Angle Microwave Radiator.—S. S. D. Jones. (*Proc. Instn elect. Engrs*, Part III, July 1950, Vol. 97, No. 48, pp. 255–258.) If a glass sphere of unit radius could be produced with a refractive index $\mu = \sqrt{(2-r^2)}$ where r is the distance from the centre, the sphere would act as a lens with a focus on the surface of the sphere. A microwave analogue has been constructed using spaced conducting sheets. The lens is free from aberrations as the feed is moved around the circumference and is therefore suitable for wide-angle scanning. The measured performance agrees well with theory.

621.396.677 : 538.31 : 538.214 2724

The Effective Permeability of an Array of Thin Conducting Disks.—Estrin. (*See* 2765.)

621.396.677.2 2725

Theoretical Investigations on the Radiation Impedance of Transmitting Aerials.—J. Patry. (*Schweiz. Arch. angew. Wiss. Tech.*, May 1950, Vol. 16, No. 5, pp. 138–147.) The theory of Hallén is extended to aerial arrays, in particular to symmetrical dipole arrays for metre waves. The two special problems considered are the interaction of parallel dipoles with parallel feed and the effect of the spacing between the two elements of a dipole. The complex general formula is simplified for the resonance case treated here. The values of expressions from which the radiation resistance can be found are given in a table referring to 12 different arrays of similar dipoles.

CIRCUITS AND CIRCUIT ELEMENTS

621.314.2.018.424.029.3 2726

Audio-Frequency Transformer with Range Extended below One Cycle per Second.—D. W. Kuester. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 255–257.) Discussion of design problems and description of a transformer for connection between a 72-Ω line and a 10-kΩ grid circuit, with a flat response curve from 0.2 c/s to 20 kc/s.

621.314.263 2727

The Magnetic-Cross Valve and its Application to Subfrequency Power Generation.—H. J. McCreary. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 450–466.) Basic theory and characteristics are discussed, showing how subharmonics may be obtained by a process of magnetic energy transference without moving parts or mutual inductance. Results of experimental analysis are used to show how a single flux vector may vary cyclically, but with different periods along two axes, resulting in the production of subharmonics. Details are given of the performance of a "Power Ringer" employing the device; this converts 60-c/s power to 20 c/s and has been in use in a telephone exchange for 4 years without attention.

621.314.3† 2728

The Magnetic Amplifier.—J. S. W. Graham. (*Strowger J.*, July 1950, Vol. 7, No. 2, pp. 104–119.) Fundamental principles are outlined and power control, amplification ratio, continuously variable control, feedback, time lag, core materials, and general design features are considered in detail. Application to rhythmic ("Rythmatic") ripple control is described, with test results.

621.314.3† 2729

The Problem of the Magnetic Amplifier and some Approaches to its Solution.—M. Liwschitz-Garik, E. J. Smith & E. Weber. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 235–254.) Various possible methods of steady-state analysis are considered and the question of the best representation of the magnetization characteristic of a core under conditions of

asymmetrical magnetization is discussed. Experimental results are given illustrating the effect of d.c. bias on the a.c. magnetization curve. Results for half-wave and full-wave magnetic amplifiers are computed by a point-by-point procedure and by a method based on the representation of the magnetization curve by three linear elements. The latter method yields satisfactory results in much the shorter time.

621.314.3† 2730

An Extension of a Theory of Magnetic Amplifiers.—R. T. Beyer & Ming-Yi Wei. (*J. Franklin Inst.*, July 1950, Vol. 250, No. 1, pp. 25–37.) The theory previously given (2730 of 1949) is extended to the case of large d.c. inputs and the presence of harmonics in the primary current, the a.c. impedance of the secondary being assumed infinite. Experimental evidence supports the calculations, which show a nonlinear relation between d.c. input and second-harmonic ouput, the latter passing through a maximum as the d.c. is increased. The influence of a third-harmonic component in the primary current is also investigated; for small input currents it may be neglected without serious error.

621.314.3† : 681.142 2731

Magnetic Amplifier Studies on the Analog Computer.—E. L. Harder, W. H. Hamilton, D. F. Aldrich, J. T. Carleton & F. N. McClure. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 222–234.) A description is given of an electrical analogue to magnetic circuits and its application to the study of such circuits. Methods of applying the analogue to specific design problems are discussed. The nonlinear characteristics of iron are reproduced by using a multiple-diode nonlinear-resistance circuit whose characteristic simulates the true B/H curve by means of 20 successive linear elements.

621.316.842 + 621.316.86 2732

Wideband Power Resistors.—H. L. Krauss & P. F. Ordung. (*Electronics*, Aug. 1950, Vol. 23, No. 8, pp. 186..194.) A 30-W carbon-film resistor 10 in. long and 1¼ in. in diameter provided a satisfactory reactance-free 500-Ω termination up to 50 Mc/s when mounted in free space, but not when near an earthed plane, owing to stray capacitance. A terminated wire-wound resistor with 8 turns/in. on a former 1 in. in diameter, with carbon resistors connecting it to the earthed plane at suitable intervals so as to satisfy the distortionless transmission-line equation $R/G = L/C$, gave very satisfactory results up to 50 Mc/s.

621.318.572 2733

Electronic Decade Counter with Direct Indication by means of Neon Lamps.—A. Peuteman. (*C. R. Acad. Sci., Paris*, 19th June 1950, Vol. 230, No. 25, pp. 2160–2162.) See also 650 of 1949 (Naslin & Peuteman).

621.318.572 : 621.3.015.7 2734

A Pulse Length Sorter and Counter.—R. J. Parent & R. W. Schumann. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 72–82.) Pulses of random length and spacing, which occur at a rate of up to 10^5 per minute, can be sorted according to duration into 15 ranges. Sorting is achieved by biased circuits fed from a step-wave circuit driven by a multivibrator, which is gated by the random pulses to be measured. The number of pulses in each range is counted by binary scaling chains following each bias circuit. Circuits are described in detail, with the aid of diagrams and waveforms.

621.319.42 2735

The Influence of Operating Conditions on the Construction of Electrical Capacitors.—A. E. Bennett & K. A. Gough. (*Proc. Instn elect. Engrs*, Part III, July 1950, Vol. 97, No. 48, pp. 231–241.)

621.392 2736

The Design of Wide-Band Phase-Splitting Networks.—W. Saraga. (*Proc. Inst. Radio Engrs*, July 1950, Vol. 38, No. 7, pp. 754–770.) A general investigation of phase-splitting networks, dealing with network analysis, network synthesis, and performance-curve approximation problems. Explicit formulae for any number of design parameters and for any required degree of approximation are stated for Taylor and Tchebycheff approximations. Clear design instructions for both simple and difficult network specifications are obtained. Novel methods are developed for obtaining dissipation compensation, for network synthesis, and for representing the approximating curves as iterated functions of two variables, with fractional index of iteration.

621.392.5 2737

Frequency Analysis of Variable Networks.—L. A. Zadeh. (*Proc. Inst. Radio Engrs*, July 1950, Vol. 38, No. 7, p. 725.) Corrections to paper abstracted in 1617 of July.

621.392.5 : 621.3.015.7† 2738

The Determination of the Impulsive Response of Variable Networks.—L. A. Zadeh. (*J. appl. Phys.*, July 1950, Vol. 21, No. 7, pp. 642–645.) "Starting with the differential equation relating the output and the input of a linear varying-parameter network, it is shown that the impulsive response of the system is related to a Green's function associated with the system through a linear operator which is the adjoint of the right-hand operator in the given differential equation. A perturbation procedure [2835 of 1948 (Gray & Schelkunoff)] for the determination of the impulsive response of a slowly varying network is outlined. Use of the method is illustrated by a simple example involving a bandwidth-modulated RC half-section."

621.392.52 2739

Continuously Adjustable Electronic Filter Networks.—G. E. Tisdale. (*Proc. Inst. Radio Engrs*, July 1950, Vol. 38, No. 7, pp. 796–798.) The use of passive RC networks is discussed in terms of standard network theory. Frequency response is largely determined by these passive networks, while valves serve to isolate the various RC sections, to raise the output level, and to provide negative feedback. Design procedure is indicated and applied to adjustable low-pass and high-pass filters.

621.392.52 2740

A Crystal Filter of Variable Selectivity with Stable Resonance Frequency and Constant Gain.—W. Kautter. (*Rev. telegr., Buenos Aires*, March 1949, Vol. 37, No. 438, pp. 137–142.) Basically, the filter consists of two i.f. amplifier units coupled by the crystal. The bandwidth is altered by detuning the two circuits in opposite directions: the resulting resonance shift is $< b_{max}/24$, where b_{max} is the maximum bandwidth, and thus falls within tolerable limits. The crystal dynamic resistance does not affect the operation of the filter, at least to a first approximation. The gain is constant and equal to that of a conventional i.f. stage over the whole band. Neutralization of the crystal dynamic capacitance, and the type of coupling required between crystal and circuits, are discussed. Crystals that are free from spurious responses near the working frequency are essential.

621.392.52 : 621.3.015.3 2741

Transient Response of Filters.—M. S. Corrington. (*Proc. nat. Electronics Conference, Chicago*, 1949 Vol. 5, pp. 519–549.) Reprint. See 60 of January.

2742

621.392.52 : 621.392.267

Low-Q Microwave Filters.—J. Reed. (*Proc. Inst. Radio Engrs*, July 1950, Vol. 38, No. 7, pp. 793–796.) An analysis of waveguide bandpass filters of the type previously investigated by Pritchard (1000 of 1948), Fano & Lawson (695 of 1948) and Mumford (1320 of 1949), in which each stage comprises two spaced inductive irises and successive stages are separated by $\lambda/4$ sections of optimum length $s + \lambda_g/4$, where s is the iris spacing. Variation with frequency of the iris susceptance has a substantial effect on the loaded Q, especially for low values of Q. The theory was checked by experiments in which pairs of brass rods were substituted for irises.

2743

621.392.52 : 621.392.267

Design Relations for the Wide-Band Waveguide Filter.—S. B. Cohn. (*Proc. Inst. Radio Engrs*, July 1950, Vol. 38, No. 7, pp. 799–803.) Simplified formulae are derived and presented graphically for the design of non-uniform waveguide structures of the type previously considered (2469 of 1949). A numerical example is worked out. Measurements were made on specially constructed waveguide sections, and the calculated values of cut-off and infinite-attenuation frequency were found reliable to within 2%.

2744

621.392.52.029.4

Continuously Adjustable Low- and High-Pass Filters for Audio Frequencies.—A. Peterson. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 550–555.) Audio-frequency filter circuits are described in which the cut-off frequency is continuously variable over a 3 : 1 range with little change in the pass-band response. Each filter section uses two capacitors, a low-Q inductor, and a twin-triode reactance circuit with control by a single potentiometer. Beyond cut-off the attenuation is about 18 db per octave.

2745

621.396.611.3

An Analysis of Triple-Tuned Coupled Circuits.—N. W. Mather. (*Proc. Inst. Radio Engrs*, July 1950, Vol. 38, No. 7, pp. 813–822.) Circuits having high Q are considered, the couplings being loose and the response symmetrical about a reference frequency. Universal response curves are derived and contour plots for the product of gain and bandwidth are given. Compared with double-tuned circuits the triple-tuned circuit has the advantages of more uniform response inside the pass band, greater rejection outside it, and a larger value for the product of gain and bandwidth.

2746

621.396.611.4

Coupling between Two Degenerate Modes through Slots Cut in the Wall of a Cavity.—Han C. Hu. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 467–472.) An analytical and graphical presentation of slot patterns is given. Experimental results obtained with a test cavity, and oscillograms showing transmission and absorption characteristics for TE_{112} and TE_{113} degeneracy are used to indicate a way of achieving a precise degree of coupling.

2747

621.396.615.14 : 621.385.029.63/.64

The Helix as Resonator for Generating Ultra High Frequencies.—van Iperen. (*See* 2944.)

2748

621.396.645

A 60-db Nonlinear Amplifier.—J. A. Carruthers. (*Canad. J. Res.*, May 1950, Vol. 28, Sec. A, No. 3, pp. 287–292.) The amplifier described has been used to drive an Esterline Angus 0–1-mA recording galvanometer as part of the apparatus for automatically recording the radiation patterns of microwave aerials. By using a v.c. the amplifier output is made approximately proportional to the logarithm of the input, thus enabling a 60-db variation of input signal to be plotted. The speed of response is limited by the galvanometer movement but is adequate for obtaining a pattern through 100° of azimuth in about two minutes. Plotting is accurate to within 1 db if care is taken to check calibration frequently.

2749

621.396.645

Cathode-Follower Amplifiers.—F. Navascues. (*Rev. Telecomunicación, Madrid*, Dec. 1949, Vol. 5, No. 18, pp. 9–29.) Study of cathode-follower circuits for a.f., i.f. and h.f. amplifiers, attenuators and impedance-matching units.

2750

621.396.645

Distributed Amplifiers: Practical Considerations and Experimental Results.—W. H. Horton, J. H. Jasberg & J. D. Noe. (*Proc. Inst. Radio Engrs*, July 1950, Vol. 38, No. 7, pp. 748–753.) Experimental results are presented corroborating the predictions made in an earlier paper (3375 of 1948). The causes of deviation from the idealized case are (*a*) attenuation due to coil losses, (*b*) attenuation due to grid losses, (*c*) grid- and anode-lead inductance, (*d*) capacitance distributed throughout the transmission-line coil windings. These effects can be corrected by using paired-anode circuits, negative-mutual circuits, or bridged-T circuits. The pass bands dealt with are of the order of 200–300 Mc/s.

2751

621.396.645 : 621.396.822

Noise Suppression in Triode Amplifiers.—A. van der Ziel. (*Canad. J. Res.*, June 1950, Vol. 28, Sec. F, No. 6, pp. 189–198.) A survey is given of recent work on noise suppression in triode amplifier stages. A theory is developed, in which the noise factor is expressed in terms of four complex quantities g_0, g_1, i_0 and i_1. g_0 and g_1 are the complex transconductances in the cathode lead and in the anode lead, respectively; i_0 and i_1 are the Fourier components of the noise currents flowing in these leads, respectively. These quantities are complex owing to transit-time effects. The theory is developed under the assumption that i_0 and i_1 are completely correlated. Experiments indicate that no complete noise suppression is possible if there is no feedback; according to the above theory this means that the real part of $(g_0 - g_1 i_0/i_1)$ is positive. Knol & Versnel showed recently that complete noise suppression can always be obtained under the above assumption of complete correlation if a suitable amount of external feedback is applied. With the help of the above theory it is shown, however, that the available power gain under those circumstances is less than unity.

2752

621.396.645.018.424 : 621.397.61 : 621.3.088.7

The Compensation for Phase Errors in Wide-Band Video Amplifiers.—A. E. Brain. (*Proc. Instn elect. Engrs*, Part III, July 1950, Vol. 97, No. 48, pp. 243–251.) The transient response of multistage amplifiers may be improved by the insertion of several sections of bridged-T or lattice networks. A method is outlined for evaluating the phase characteristic of an amplifier with an arbitrary amplitude characteristic. Application of three suitable phase-correction circuits to a 16-stage amplifier reduced the rise time by about 33% and the overshoot from over 20% to less than 9%.

2753

621.396.645.094

On the Problem of Distortionless Amplification of D.C. Pulses with an A.C. Amplifier.—R. Gauger. (*Z. angew. Phys.*, April 1950, Vol. 2, No. 4, pp. 179–188.) For investigation of transients in a circuit a "transfer function" is found useful. This is defined as the ratio of output to input voltage as a function of time when a step voltage is applied to the circuit; it is therefore dependent on the circuit time-constant. The transfer function is calculated for amplifiers with and without distortion correction and with up to 3 stages. The

influence of the RC combinations in cathode and screen-grid circuits is considered. By use of CR or LR correcting networks the transfer function of a RC-coupled amplifier can be made practically independent of time up to half the original time constant. For pulses of duration less than this such an amplifier is suitable. The compensated amplifier has a lower minimum operating frequency and gives very little phase change at low frequencies. Distortion-free amplification can be achieved for square waves of fundamental frequency at least twice as high as the limiting frequency of the non-compensated amplifier.

621.396.645.35 : 621.317.755 2754

D.C. Amplifier Techniques in Oscillography.—Maron. (*See* 2838.)

621.396.822 : 519.283 2755

Statistical Prediction of Noise.—Y. W. Lee & C. A. Stutt. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 342–365.) Pertinent results in Wiener's theory of prediction (2465 of October) and their application to the prediction of filtered noise are discussed. Calculations leading to the required network for prediction of such noise are given in detail. Results in the form of a simultaneous display of predictor input and output waveforms show that the theory provides a useful approach to certain communication problems.

681.142 2756

Feedback in Electrical Analogue [impedance] **Chains and Networks.**—P. Grivet & Y. Rocard. (*Rev. sci., Paris*, April/June 1949, Vol. 87, No. 3302, p. 85.) The introduction of reaction into such circuits extends their mathematical application.

621.314.3† 2757

The Transistor Amplifier. [Book Review]—U. Krabbe. Publishers: Ejnar Munksgaard, Copenhagen, 1949, 176 pp., Dan. kr. 22. Obtainable from Bonniers, 605 Madison Ave, New York 22, at $5.50. (*Electronics*, Aug. 1950, Vol. 23, No. 8, p. 132.) "An excellent treatise on saturable-core reactors and their applications. The author, a competent mathematician, has shown rare ability in expressing equations in words prior to resorting to formulas . . . . It . . . will constitute an invaluable addition to any engineering library."

621.318.42 2758

The Theory and Design of Inductance Coils. [Book Review]—Publishers: Macdonald, London, 180 pp., 18s. (*Electrician*, 18th Aug. 1950, Vol. 145, No. 3766, p. 425.) "The object of this book is to explain, in general terms, the underlying theory on which the design of inductance coils is based, and then to show how the theory can be simplified by the use of certain approximations and to what extent they are justified . . . It is very well produced, carries a small, but useful, bibliography and should be a valuable reference work."

GENERAL PHYSICS

535.222 2759

A Measurement of the Velocity of Light.—R. A. Houstoun. (*Proc. roy. Soc. Edinb. A*, 1949/1950, Vol. 63, Part 1, pp. 95–104.) Full paper. Short account abstracted in 1896 of August.

535.314 2760

Improvement of the Optical Schlieren Method by Minimum Ray Indication.—H. Wolter. (*Ann. Phys., Lpz.*, 1st April 1950, Vol. 7, Nos. 3/4, pp. 182–192.)

537.311.33 : 621.314.634 2761

Experimental Examination of Rectifier Theory as Applied to the Selenium Rectifier.—Henkels. (*See* 2798.)

537.312.8 : [539.23 + 669-426 2762

The Conductivity of Thin Wires in a Magnetic Field.—R. G. Chambers. (*Proc. roy. Soc. A*, 7th Aug. 1950, Vol. 202, No. 1070, pp. 378–394.) A thin metal wire or film has a lower electrical conductivity than the bulk material if the thickness is comparable with the electron mean free path. This problem is examined from the kinetic-theory standpoint and the conclusions are applied to the case of a thin wire in an axial magnetic field. Experimental results are given which agree with the theoretical predictions.

537.525 : [537.542.2 + 536.49 2763

The Role of Cathode Temperature in the Glow Discharge.—H. Jacobs & J. Martin. (*J. appl. Phys.*, July 1950, Vol. 21, No. 7, pp. 681–685.) A study of the effect of the temperature of oxide-coated cathodes on cold-cathode glow discharges in neon, argon and neon/argon and Hg-vapour/argon mixtures.

537.562 : 538.561 2764

Unstable Oscillations in an Electron Gas.—K. G. Malmfors. (*Ark. Fys.*, 15th March 1950, Vol. 1, Part 6, pp. 569–578. In English.) An analytical treatment of the problem of electron beams in a magnetic field. At high densities an appreciable part of the electron current is collected by negative electrodes and noise level is high, indicating the existence of an energy-interchange mechanism other than ordinary collision; unstable oscillations exist at all frequencies. Such effects may afford a possible explanation of solar and galactic noise.

538.31 : 538.214 : 621.396.677 2765

The Effective Permeability of an Array of Thin Conducting Disks.—G. Estrin. (*J. appl. Phys.*, July 1950, Vol. 21, No. 7, pp. 657–670.) "When an alternating magnetic field is parallel to the disk faces, the field is undisturbed and the relative permeability coefficient is unity. When the alternating magnetic field is normal to the disk faces, circulating currents are induced on them. The boundary-value problem of determining the current distribution on a single perfectly conducting disk is carried out in detail for the case where the disk diameter is small compared to the wave-length. This current distribution is found to be representable by a magnetic dipole. If the disks in an array are far enough apart to neglect interaction, a simple summation of the dipole moments shows the array to have a diamagnetic susceptibility in the direction normal to the disk faces. Combining this result with an expression for the dielectric coefficient, which was developed earlier by Kock [2176 of 1948] the constants of the anisotropic array are completely specified."

538.52/.53 2766

Self Inductance of a Spherical Metal Shell and Mutual Inductance with an Endless Solenoid.—A. Colombani. (*C. R. Acad. Sci., Paris*, 19th June 1950, Vol. 230, No. 25, pp. 2158–2160.) Simple formulae, which may be of practical importance in h.f. work, are derived.

538.566 : 535.421 2767

Rigorous Theory of the Diffraction of Plane Electromagnetic Waves at a Perfectly Conducting Circular Disk and at a Circular Aperture in a Perfectly Conducting Plane Screen.—J. Meixner & W. Andrejewski. (*Ann. Phys., Lpz.*, 1st April 1950, Vol. 7, Nos. 3/4, pp. 157–168.) A rigorous solution which satisfies the radiation and boundary conditions and facilitates numerical calculation is obtained by representing the e.m. field by means of the Hertzian vector potential and developing the expression for the wave in the form of spheroidal functions. The field and the induced-current distribution in

the diffracting disk are fully investigated for the particular case of relatively long waves. The complementary problem of diffraction at a circular aperture in a screen of infinite extent may be treated similarly, by virtue of the validity of the generalized Babinet principle.

538.566 : 537.562 2768

Electro-Magneto-Ionic Waves.—V. A. Bailey & K. Landecker. (*Nature, Lond.*, 12th Aug. 1950, Vol. 166, No. 4215, pp. 259–261.) Experiments have been made, using gas-discharge tubes subjected to magnetic fields, to test the theory that discrete frequency bands exist in which e.m. waves can grow in an ionized medium, developing strong e.m. noise from initially small random perturbations. Various gases, pressures and electrode arrangements were used. For fields $\geq$ 100 gauss applied along the tube the expected bands always appeared; some observed noise intensities are shown graphically. From the positions of the bands conclusions are drawn regarding the details of wave propagation. Observations were also made on a thyratron with magnetic field applied transversely. The experiments demonstrate the value of the theory and supply a rough model of a sunspot emitter of enhanced solar noise. See also 1665 of July (Bailey & Roberts), 2785 and 3406 of 1949 (Bailey).

548.232 : 538.221 2769

Oriented Crystals: their Growth and their Effects on Magnetic Properties.—W. Morrill. (*Gen. elect. Rev.*, Aug. 1950, Vol. 53, No. 8, pp. 16–21.) Practical use of the anisotropic properties of metals is well advanced and the controlled growth of oriented crystals has produced exceptional magnetic properties in certain commercial materials. Study of crystal orientation and growth is proceeding in many laboratories and it is hoped that eventually any degree of preferred crystal orientation in any magnetic material will be commercially practicable.

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.2/.8 : 538.12 2770

The Hydromagnetic Equations.—W. M. Elsasser. (*Phys. Rev.*, 1st July 1950, Vol. 79, No. 1, p. 183.) Using 'Maxwellian' electrodynamics, equations analogous to the hydrodynamic equations are derived for the currents, and associated magnetic fields, carried by cosmic fluids. These phenomena are of interest for solar, stellar and sunspot magnetism, geomagnetism, magnetic fields in stellar atmospheres and in interstellar space, and the related problem of galactic radio noise.

523.841.2 : 538.12 2771

Stellar Magnetic Fields.—H. W. Babcock. (*Nature, Lond.*, 12th Aug. 1950, Vol. 166, No. 4215, pp. 249–251.) An account of observations of the magnetic fields of certain variable stars. The star HD 125248 appears to be a magnetic dipole oscillator, with a fundamental frequency 1.25 microcycles/sec, radiating about 10^{12} kW on both fundamental and second harmonic.

537.562 : 538.566 2772

Electro-Magneto-Ionic Waves.—Bailey & Landecker. (*See* 2768.)

551.51 : 535.326] : 621.396.11 2773

Determination of Modified Index-of-Refraction over the Gulf of Mexico from Radio Data.—A. W. Straiton & A. H. LaGrone. (*J. appl. Phys.*, July 1950, Vol. 21, No. 7, pp. 661–666.) Measurements of signal strength and phase of 3.2-cm waves for a 26.5-mile over-sea path were made during June and July 1949. The radio data are analysed, using Macfarlane's theory (3487 of 1948) to give the modified refractive-index curves, which are compared with those deduced from meteorological observations.

551.510.535 + 523.5 2774

A Comparison of Meteor Activity with Occurrence of Sporadic E Reflections.—V. C. Pineo. (*Science*, 14th July 1950, Vol. 112, No. 2898, pp. 50–51.) Previously presented evidence (*ibid.*, 1949, Vol. 110, p. 280) that the echo from a meteor trail differs in character from a sporadic-E reflection is supported by a statistical study of continuous observations made at the National Bureau of Standards from 1st November 1948 to 30th April 1949. Sporadic-E is regarded as long-duration abnormality, as distinct from ionization bursts, and extreme care was taken to ensure that only reflections of true sporadic-E type were counted. Monthly average values of (*a*) hourly rate of meteor reflections, and (*b*) percentage of time of occurrence of sporadic-E reflections, show characteristic maxima at about 0600 EST and midday respectively. A scatter diagram gives no indication of correlation between the two quantities. Day-to-day curves for the month of January show no similarity. The data thus indicate that sporadic-E reflections are unrelated to meteor phenomena, at least to those detectable on 27.2 Mc/s.

551.510.535 2775

Data on the F_2 Layer of the Ionosphere [analysed] **according to the Parabola Model.**—E. Theissen. (*Naturwissenschaften*, July 1950, Vol. 37, No. 14, pp. 334–335.) Diurnal, seasonal and long-term ionospheric variations observed at two German stations are examined.

551.594.51 2776

On the Origin of Ten-Centimeter Radiation from the Polar Aurora.—P. A. Forsyth, W. Petrie & B. W. Currie. (*Canad. J. Res.*, May 1950, Vol. 28, Sec. A, No. 3, pp. 324–335.) Short-lived bursts of 10-cm radiation from auroral displays have been received by radar equipment. The sources of continuous radiation from a partially ionized medium are briefly discussed. From a knowledge of the constants of the equipment used it is deduced that the power density at the receiver is at least 2×10^{-19} W/m², and it seems that the most likely source of this radiation is a plasma oscillation of the ionized volume associated with the auroral display. If this is so, the electron density in localized regions must be of the order of 10^{11}/cm³.

521.030 : 537.5 2777

Cosmical Electrodynamics. [Book Review]—H. Alfvén. Publishers: Clarendon Press, Oxford, & Oxford University Press, London, 1950, 238 pp., 25s. (*Nature, Lond.*, 12th Aug. 1950, Vol. 166, No. 4215, p. 243.) "A short general survey is followed by three chapters discussing the motion of charged particles in a magnetic field, electric discharges, and the magneto-hydrodynamic waves which Alfvén himself first discovered. The ideas developed in these three chapters are then applied in a further three chapters to solar physics (sunspots, chromospheric and coronal temperatures, prominences, etc.), magnetic storms and aurorae, and cosmic radiation."

LOCATION AND AIDS TO NAVIGATION

621.396.9 2778

Thunderstorm Tracks by Radar.—R. F. Jones. (*Weather, Lond.*, June 1950, Vol. 5, No. 6, pp. 224–225.) Radar photographs taken near Dunstable of thunderstorms at Evesham and Birmingham on 13th July 1949 are shown and discussed.

621.396.9 : 531.768 2779

Theoretical Limit to Time-Difference Measurements.—Richman. (*See* 2824.)

621.396.933 2780

Traffic-Handling Capacity of Paired-Pulse Coding for 100-Channel Distance-Measuring Equipment (DME).—C. J. Hirsch. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 366–386.) See 1918 of August.

621.396.933 2781

Radio Aids to Navigation at the Ministro Pistarini Airport (Buenos Aires).—P. N. Guzzi. (*Rev. telegr., Buenos Aires*, June 1949, Vol. 37, No. 441, pp. 307–312.) The aids provided, chosen to conform to I.C.A.O. recommendations, will include G.C.A. and an instrument landing system.

621.396.933 2782

Instrumental Landing System for Aircraft.—A. N. Bhattacharyya. (*Indian J. Phys.*, Jan. 1949, Vol. 23, No. 1, pp. 13–18.) General discussion of a system using the interference of u.h.f. waves radiated from two aerials excited in the same phase with a common frequency.

621.396.933 2783

Microwave Radio Blind-Landing Systems for Aircraft.—A. N. Bhattacharyya. (*Indian J. Phys.*, Feb. 1949, Vol. 23, No. 2, pp. 88–92.) Two sharply defined beams rotating in a plane inclined to the earth's surface at the glide angle are produced respectively by two horn aerials rotating in opposite directions. The beams are synchronized to intersect in the vertical plane midway between the aerials, thus defining a glide path. Operating frequency is of the order of 20 kMc/s.

MATERIALS AND SUBSIDIARY TECHNIQUES

531.788.12 2784

A Rotary McLeod Gauge.—M. Axelbank. (*Rev. sci. Instrum.*, June 1950, Vol. 21, No. 6, pp. 511–513.) The new model described is improved in respect of portability, robustness and ease of operation.

531.788.7 2785

Extension of the Low-Pressure Range of the Ionization Gauge.—R. T. Bayard & D. Alpert. (*Rev. sci. Instrum.*, June 1950, Vol. 21, No. 6, pp. 571–572.) The new model described has been used to measure pressures of the order of 10^{-10} mm Hg.

538.221 : 546.56.723.722 2786

Magnetic Properties and Structure of the Quadratic Phase of Ferrite of Copper.—L. Weil, F. Bertaut & L. Bochirol. (*J. Phys. Radium*, May 1950, Vol. 11, No. 5, pp. 208–212.)

538.221 : 621.317.411.029.5 2787

Determination of the Apparent Permeability and *Q* Factor of a Magnetic Powder at High Frequency.—A. Colombani. (*J. Phys. Radium*, May 1950, Vol. 11, No. 5, pp. 201–207.) The resultant internal and external fields are first calculated for an isolated particle in a h.f. magnetic field. The results are applied to a uniform distribution of particles within a medium. From the complex permeability found, the *Q* factor and flux reduction factor are easily deduced. Calculated values, dependent on frequency, conductance and grain size, are in good agreement with experimental results. See also 1172 of May.

538.221 : 669.231.15 2788

Magnetic Properties of Platinum-Iron Alloys: Part 2.—A Kussmann & G. von Rittberg. (*Ann. Phys., Lpz.*, 1st April 1950, Vol. 7, Nos. 3/4, pp. 173–181.)

For alloys containing 30 to 63% Pt by weight, magnetostriction effects are the highest yet observed in ferromagnetic materials. Optimum properties for permanent magnets are obtained when the Pt content is 70%. Magnetostriction in this case is very small.

538.221 : 669.231.74 2789

Ferromagnetic Platinum-Manganese Alloys.—M. Auwärter & A. Kussmann. (*Ann. Phys., Lpz.*, 1st April 1950, Vol. 7, Nos. 3/4, pp. 169–172.) The ferromagnetic properties exhibited by Pt-Mn alloys containing 6 to 16% Mn by weight are attributed to the ordered arrangement of the atoms in the mixed crystals as Pt_3Mn. Magnetic-saturation and thermal-expansion curves, lattice constants and transition temperatures are given.

538.652 : 669.018.58 2790

Evaluation of the Magnetostrictive Properties of Hiperco.—H. Sussman & S. L. Ehrlich. (*J. acoust. Soc. Amer.*, July 1950, Vol. 22, No. 4, pp. 499–506.) A description of tests made to evaluate the suitability of the alloy as a material for transducers. The performance criteria are established, and the properties and performance of hiperco, nickel and permendur are compared. For remanence operation hiperco is satisfactory for hydrophone use, but it is inferior to the other materials for high-power underwater projection. Its performance is improved by polarizing above remanence.

546.217 : 621.317.335.3.029.64 2791

The Permittivity of Air at a Wavelength of 10 Centimeters.—Phillips. (*See* 2827.)

546.471.61 : [537.311 + 537.323 + 538.632 2792

Electronic Processes in Zinc Fluoride and in the Manganese-Activated Zinc Fluoride Phosphor.—J. H. Crawford, Jr, & F. E. Williams. (*J. chem. Phys.*, June 1950, Vol. 18, No. 6, pp. 775–780.) Measurements of the temperature dependence of electrical conductivity and thermal e.m.f. for ZnF_2 and ZnF_2–Mn, and of the Hall coefficient and rectifying power at 25°C for ZnF_2.

546.472.21 : 535-37 2793

The Poisoning of Cathodoluminescence in Silver-Activated Cubic Zinc Sulfide.—S. Larach. (*J. chem. Phys.*, June 1950, Vol. 18, No. 6, p. 896.) Small amounts of Co, Fe or Ni sulphates were crystallized together with the ZnS–Ag phosphor. The poisoning effect was about the same for all three impurities. Cathode rays were used for excitation.

548.0 : 537 2794

Ferroelectric Crystals.—B. Matthias. (*Helv. phys. Acta*, 3rd Feb. 1950, Vol. 23, Nos. 1/2, pp. 167–170. In German.) Fundamental research carried out at the E.T.H., Zürich, is described briefly. The possibility of finding other ferroelectric crystals isomorphic with $BaTiO_3$ is investigated.

549.514.51 : 548.523 2795

Growing Large Quartz Crystals.—A. C. Walker & E. Buehler. (*Industr. Engng Chem.*, July 1950, Vol. 42, No. 7, pp. 1369–1375.) Full paper. Summary abstracted in 411 of 1949.

621.3.015.3 : 546.217 2796

A Note on Ultra-High-Frequency Gas Breakdown.—W. A. Prowse. (*Proc. Instn elect. Engrs*, Part III, July 1950, Vol. 97, No. 48, pp. 253–254.) Some results obtained by Pim (2246 of 1949) show breakdown voltages which increase as the gap width is reduced. An explanation is here given as to why the spark, under such conditions, does not simply transfer to a point of greater gap width.

621.3.087.45 2797

Closed-Cycle Recording Oscillographs.—H. Cissel & R. Ruhland. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 4–10.) Review of available equipment and description of an 8-channel pen recorder, with servo-*motor pen drive*, for use in flight tests.

621.314.634 : 537.311.33 2798

Experimental Examination of Rectifier Theory as Applied to the Selenium Rectifier.—H. W. Henkels. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 23–39.) Recent work at the University of Pennsylvania on the correlation of rectifier theory with experiment is examined. The variables in Schottky's theory are treated individually. The electrical properties of single crystals, as well as microcrystalline specimens, are examined in their relation to the Se rectifier. To explain bulk properties, a model of microcrystalline selenium must possess layers of high resistance at crystal grain boundaries, and surface layers on the crystallites of quite low resistance.

621.315.592† : 539.23 2799

Concerning the Theory of Photoconductivity in Infra-red-Sensitive Semiconducting Films.—E. S. Rittner. (*Science*, 23rd June 1950, Vol. 111, No. 2895, pp. 685–688.) Critical discussion of various theories, with a more general explanation of the effects observed in such films which avoids the difficulty of the exact balancing of impurities.

621.315.612.4 : 546.431.82 2800

The Dielectric Properties of Barium Titanate.—R. E. Averbukh & M. S. Kosman. (*Zh. eksp. teor. Fiz.*, Nov. 1949, Vol. 19, No. 11, pp. 965–970.) The dependence of the dielectric constant of $BaTiO_3$ on temperature and on field strength is investigated by a new ballistic method. The expression for the constant consists of two terms which vary differently.

621.315.612.6 : 537.311 2801

Electrical Conduction in Glass.—P. L. Kirby. (*Brit. J. appl. Phys.*, Aug. 1950, Vol. 1, No. 8, pp. 193–202.) The mechanism of electrical conduction in glass is discussed in the light of modern theories of its atomic structure. Variation of conductivity with composition is explained by reference to the valency requirements of the network atoms, and the temperature variation of conductivity is examined. The relative magnitudes of the dielectric absorption current and the true conduction current are considered, and the total loss angle is calculated for various temperatures to illustrate the transition from a dielectric to an ionic conductor.

621.315.616.7 2802

A New Dry-Type Insulation for Instrument Transformers.—R. A. Pfuntner, R. E. Franck & F. R. D'Entremont. (*Elect. Engng, N.Y.*, July 1950, Vol. 69, No. 7, pp. 594–599.) Butyl, a rubber-like material, can be moulded completely round core and coils; its dielectric properties are excellent over a wide range of temperature and humidity and it is chemically stable.

621.395.625.3 : 681.6 2803

A New Magnetic Record Duplicating Process.—M. Camras. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 258–261.) A rapid contact-printing process in which the blank is held against a master tape while the two are subjected to a h.f. magnetic field. See also 2804 below.

621.395.625.3 : 681.6 2804

Duplication of Magnetic Tape Recordings by Contact Printing.—R. Herr. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 262–268.) Discussion of a method identical in principle with that noted in 2803 above, and brief description of practical equipment. The method is not limited to tape records, but can be applied to records on disks, drums, etc. It does not seem applicable to the duplication of records on wire.

621.946.148.12 2805

High-Voltage and Electrolytic Drilling of Diamond Dies.—(*Machinery, Lond.*, 25th May 1950, Vol. 76, No. 1961, pp. 743–744.) Short account of method noted in 3944 of 1947.

666.1.037.5 : 539.319 2806

Stresses in Glass/Metal Seals: Part 1 — The Cylindrical Seal.—F. W. Martin. (*J. Amer. ceram. Soc.*, 1st July 1950, Vol. 33, No. 7, pp. 224–229.) Consideration of viscous flow during cooling of a beaded wire seal following annealing treatment leads to a modification of the theory of Hull & Burger (1184 of 1935); good agreement is then obtained between theoretical and experimental values of stress in beaded wire seals. Cylindrical seals with the metal outside are also considered. The expansion necessary for the best match depends on the geometry of the seal. In general, metal/glass seals should be annealed at a temperature above that used for the glass alone.

537.228.1 : 548.0 2807

Piezoelectric Crystals and their Application to Ultrasonics. [Book Review]—W. P. Mason. Publishers: D. Van Nostrand, New York, 508 pp., $7.50. (*J. acoust. Soc. Amer.*, July 1950, Vol. 22, No. 4, pp. 519–520.)

MATHEMATICS

519.242 : 621.396.1 2808

An Extension of Wiener's Theory of Prediction.—L. A. Zadeh & J. R. Ragazzini. (*J. appl. Phys.*, July 1950, Vol. 21, No. 7, pp. 645–655.) "The signal (message) component of the given time series is assumed to consist of two parts, (*a*) a non-random function of time which is representable as a polynomial of degree not greater than a specified number n and about which no information other than n is available, and (*b*) a stationary random function of time which is described statistically by a given correlation function. (In Wiener's theory, the signal may not contain a non-random part except when such a part is a known function of time.)

The impulsive response of the predictor or, in other words, the weighting function used in the process of prediction is required to vanish outside of a specified time interval $0 \leq t \leq T$. (In Wiener's theory T is assumed to be infinite.)

The theory developed in this paper is applicable to a broader and more practical class of problems than that covered in Wiener's theory. As in Wiener's theory, the determination of the optimum predictor reduces to the solution of an integral equation which, however, is a modified form of the Wiener-Hopf equation. A simple method of solution of the equation is developed. This method can also be applied with advantage to the solution of the particular case considered by Wiener. The use of the theory is illustrated by several examples of practical interest." See also 2465 of October.

681.142 2809

Linear Electronic Analog Computer Design.—C. A. Meneley & C. D. Morrill. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 48–63.) Discussion of problems of design and a description of a complete computer with power supplies, housed in a single 6-ft × 19-in. cabinet.

681.142 2810

Feedback in Electrical Analogue [impedance] **Chains and Networks.**—P. Grivet & Y. Rocard. (*Rev. sci., Paris*, April–June 1949, Vol. 87, No. 3302, p. 85.) The introduction of feedback in such circuits extends their mathematical application.

681.142 2811

An Electronic Integral-Transform Computer and the Practical Solution of Integral Equations.—H. Wallman. (*J. Franklin Inst.*, July 1950, Vol. 250, No. 1, pp. 45–61.) Description of the principle and discussion of the applications of a proposed instrument performing computations in about 0.1 sec and presenting results graphically on a c.r. tube screen.

681.142 : 512.25 2812

A Computer for Solving Secular Equations.—J. F. Storm. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 98–106.) A manually operated analogue computer for obtaining the real roots of a 3-by-3 set of secular equations. Modifications required for automatic operation are discussed.

681.142 : 621.314.3† 2813

Magnetic Amplifier Studies on the Analog Computer.—Harder, Hamilton, Aldrich, Carleton & McClure. (*See* 2731.)

681.142 : 621.389 2814

The Photoformer in Anacom Calculations.—H. W. Schultz, J. F. Calvert & E. L. Buell. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 40–47.) Description of a device for generating a wide variety of functions by making a c.r. beam follow the edge of an appropriate mask, with discussion of its use as a non-linear element in an analogue computer.

517.31/.36 + 517.7 (083.81) 2815

Integraltafel. Erster Teil: Unbestimmte Integrale. [Book Review]—W. Gröbner & N. Hofreiter. Publishers: Springer-Verlag, Vienna, 1949, 166 pp., $5.40. (*Quart. appl. Math.*, Jan. 1950, Vol. 7, No. 4, p. 474.) "This table of indefinite integrals appears to be more complete than others generally available. There are three sections . . . entitled Rational Integrands . . ., Algebraic Irrational Integrands . . ., and Transcendental Integrands. . . ." Part 2, on definite integrals, is in preparation.

517.512.2 + 517.942.82 2816

Fourier Methods. [Book Review]—P. Franklin. Publishers: McGraw-Hill Book Co., New York, 1949, 289 pp., $4.00. (*J. Franklin Inst.*, March 1950, Vol. 249, No. 3, pp. 258–259.) This is a book written for students. "The author broadly interprets Fourier methods as any analysis or synthesis of functions by a linear process applied to sines, cosines, or to complex exponentials . . . [He] has successfully treated the subject of Fourier series and transforms and Laplace transforms in an introductory manner which . . . is adequate for many practical problems."

517.564.2(083.5) 2817

Tables of Inverse Hyperbolic Functions. [Book Review]—Computation Laboratory, Harvard University. Publishers: Harvard University Press, Cambridge, Mass., 1949, 290 pp., $10.00. (*Quart. appl. Math.*, Jan. 1950, Vol. 7, No. 4, p. 475.) First and second differences are given, and the functions are tabulated to 9 decimal places.

517.564.3(083.5) 2818

Tables of Bessel Functions of Fractional Order: Vol. 2. [Book Review]—Computation Laboratory, National Bureau of Standards. Publishers: Columbia University Press, New York, 1949, 363 pp., $10.00. (*Quart. appl. Math.*, Jan. 1950, Vol. 7, No. 4, p. 475.) $I_\nu(x)$ is tabulated for $\nu = \pm\frac{1}{3}, \pm\frac{1}{4}, \pm\frac{1}{6}, \pm\frac{1}{8}, \pm\frac{1}{12}$, x ranging from 0 to 13 for the negative values of ν and from 0 to 23 for the positive values of ν. $e^{-x}I_\nu(x)$ is tabulated for the same values of ν and for x ranging from 25 to 30 000. Functions are tabulated to 10 decimal places or 10 significant figures. Auxiliary tables facilitate interpolation in the x and ν directions.

517.564.3(083.5) 2819

Tables of the Bessel Functions of the First Kind of Orders Fifty-Two through Sixty-Three. [Book Review]—Computation Laboratory, Harvard University. Publishers: Harvard University Press, Cambridge, Mass., 1949, 544 pp., $8.00. (*Quart. appl. Math.*, Jan. 1950, Vol. 7, No. 4, p. 479.) $J_{52}(x)$, $J_{53}(x)$, . . . $J_{63}(x)$ are tabulated to 10 decimal places for values of x ranging from 0 to 100 in steps of 0.01.

517.7 2820

Anwendung der elliptischen Funktionen in Physik und Technik. [Book Review]—F. Oberhettinger & W. Magnus. Publishers: Springer, Berlin, 1949, 126 pp., paper cover, 15.60 DM, bound, 18.30 DM. (*Naturwissenschaften*, May 1950, Vol. 37, No. 10, p. 237.) Includes a series of examples of two-dimensional problems in electrostatics and hydromechanics, particularly field calculations and current flow in channels of rectangular or elliptical cross-section, and Tchebycheff approximations in filter circuit theory.

517.9 2821

Partial Differential Equations in Physics. [Book Review]—A. Sommerfeld. Publishers: Academic Press, New York, 1949, 335 pp., $5.80. (*Science*, 21st April 1950, Vol. 111, No. 2886, p. 414.) A translation by E. G. Straus of the sixth volume of Sommerfeld's 'Lectures on Theoretical Physics'. "The last chapter deals with the propagation of radio waves and serves as an illustration of many of the general methods developed in earlier chapters. The chief merit of the book lies in its skilful handling of complex problems, by the use of a minimum of mathematical formalism and a maximum of physical intuition."

518.12 2822

Numerical Calculus. [Book Review]—W. E. Milne. Publishers: Princeton University Press, Princeton, N.J., 1949, 393 pp., $3.75. (*Quart. appl. Math.*, Jan. 1950, Vol. 7, No. 4, pp. 478–479.) An elementary presentation, covering approximations, interpolation, finite differences, numerical integration and curve fitting.

MEASUREMENTS AND TEST GEAR

531.761 : 621.387.424† 2823

A Direct-Reading Device for Measuring Dead Time and Recovery Time of Geiger Counters.—Epprecht. (*See* 2864.)

531.761 : 621.396.9 2824

Theoretical Limit to Time-Difference Measurements.—D. Richman. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 203–210.) Theoretical relations are derived between the accuracy with which a signal may be located in time, and the various factors which determine the accuracy. These are (*a*) signal/noise ratio, (*b*) modulation bandwidth, (*c*) signal duration, (*d*) signal frequency. The relations can be used to compute the signal/noise ratio required in systems of prescribed bandwidth, signal duration and accuracy.

621.3.089.6 : 621.396.615.085.41 2825

Automatic Calibration of Oscillator Scales.—W. J. Means & T. Slonczewski. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 217–221.) Long

frequency scales used in heterodyne oscillators are calibrated by recording photographically on a strip of motion-picture film the image of a master scale which continuously indicates the instantaneous frequency of the oscillator.

621.317.31.32 : 621.396.645 **2826**

Notes on Voltage, Current and Charge Measurements by means of Valve Amplifiers.—W. Böer. (*Ann. Phys., Lpz.*, 1st April 1950, Vol. 7, Nos. 3/4, pp. 193–208.) Two parameters are defined by means of which different types of apparatus can be compared: (*a*) electrical resolving power, which is a measure of the least difference detectable between two currents of 1-sec duration; (*b*) pulse sensitivity. Estimates are made of the disturbing effect of fluctuations originating in batteries, resistors and valves, and noise effects in grounded-grid and free-grid valves are considered. Practical measurement limits for voltage, current and charge are deduced. Some fifty references are given.

621.317.335.3.029.64^5 : 546.217 **2827**

The Permittivity of Air at a Wavelength of 10 Centimeters.—W. E. Phillips. (*Proc. Inst. Radio Engrs*, July 1950, Vol. 38, No. 7, pp. 786–790.) Measurements of the permittivity of air as a function of water-vapour content, at atmospheric pressure and temperature, support the results of previous workers regarding the important effect of atmospheric water-vapour content on the refraction of u.h.f. waves. Measurements on dry air and water vapour at reduced pressure are also recorded. Permittivity is determined by comparing the wavelengths of standing waves in a cylindrical cavity resonator when evacuated to a pressure of 0.01 mm Hg and when containing the air sample under test. The following values for permittivity were obtained: dry air at 759.09 mm Hg and 25.5°C, 1.0005548; dry air at reduced pressure and 22°C, 1.0003934_4 at 555.48 mm Hg and 1.0001209_8 at 180.08 mm Hg; moist air, 1.000806 at 752.45 mm Hg, 22°C and 100% humidity, falling to 1.000668 at 756.45 mm Hg, 19°C and 55.7% humidity.

621.317.361 **2828**

On the Problem of Unequivocal Frequency Measurement by Comparison with Fixed Standard Frequencies.—H. M. Schmidt. (*Z. angew. Phys.*, May 1950, Vol. 2, No. 5, pp. 219–223.) In the method discussed the unknown frequency f_x is heterodyned with (*a*) a suitable harmonic nf_0 of the standard frequency f_0, and (*b*) a second standard-frequency source f_0 with a known phase displacement ϕ. The phase difference of the difference frequencies produced is $\pm n\phi$ according as f_x is higher or lower than nf_0. The number n is given by the ratio of the phase angle for the difference frequencies to that for the fundamentals.

621.317.361 : 621.396.611.21 **2829**

Crystal Resonators as Frequency Substandards.—F. J. M. Laver. (*Proc. Instn elect. Engrs*, Part III, July 1950, Vol. 97, No. 48, p. 252.) Discussion on 1453 of June.

621.317.42 **2830**

Notes on the Theory and Practice of Magnetic Field-Strength Comparators of the Förster Type.—M. Wurm. (*Z. angew. Phys.*, May 1950, Vol. 2, No. 5, pp. 210–219.) Discussion of the principle of and design improvements for the premagnetized coil-type meter. See also 1470 of 1941 (Förster).

621.317.714.011.6 **2831**

The Measurement of the Time Constant of a Critically Damped Meter.—S. F. Pearce. (*J. sci. Instrum.*, July 1950, Vol. 27, No. 7, pp. 202–203.) The performance of critically damped meters, such as are required as the final indicating instrument in a receiver used for the measurement of radio interference, is analysed and a simple method is described for measurement of the time constant.

621.317.714.029.62 **2832**

Electrodynamic Ammeter for Very High Frequencies.—(*Tech. Bull. nat. Bur. Stand.*, July 1950, Vol. 34, No. 7, pp. 103–104.) Short description of an instrument developed at the National Bureau of Standards by M. Solow. It consists essentially of a coaxial transmission line with a copper wire ring about 1 cm in diameter suspended between the inner and outer conductors by a quartz fibre. When current flows in the line, a torque is exerted on the ring and its value is indicated optically. The instrument is calibrated by measurements at both 300 Mc/s and 150 Mc/s.

621.317.729 : 621.396.677 **2833**

Electrolytic-Tank Measurements for Microwave Metallic Delay-Lens Media.—S. B. Cohn. (*J. appl. Phys.*, July 1950, Vol. 21, No. 7, pp. 674–680.) The l.f. index of refraction of a delay-lens medium can be calculated from electrolyte-tank measurements on single elements. The proximity between adjacent elements is taken into account. Apparatus and method are described and results are tabulated for three types of delay-lens structure.

621.317.73 **2834**

Admittance Analyzer.—W. B. Bernard. (*Electronics*, Aug. 1950, Vol. 23, No. 8, pp. 107–109.) The admittance to be measured is connected across a tuned circuit which is then retuned; the change of capacitance to restore resonance gives the unknown susceptance, and the conductance is calculated from $G = (E/e - 1)/R$, where E is the voltage across the retuned circuit and a known resistance R in series with it, and e is the voltage across the retuned circuit alone. Resistance range was found to be 10 Ω to 1 MΩ at frequencies up to 1 Mc/s. At higher frequencies the upper limit is $1/f$ MΩ, where f is in Mc/s. A detailed circuit diagram is given of an instrument which has proved very suitable for aerial measurements on site.

621.317.73.029.62/.63 **2835**

Discontinuities in Concentric-Line Impedance-Measuring Apparatus.—M. H. Oliver. (*Proc. Instn elect. Engrs*, Part III, July 1950, Vol. 97, No. 48, p. 242.) Discussion on 1188 of May.

621.317.73.083.5 **2836**

Correction Factors for Slotted Measuring Lines at Very High Frequencies.—R. G. Medhurst & S. D. Pool. (*Proc. Instn elect. Engrs*, Part III, July 1950, Vol. 97, No. 48, pp. 223–230.) Errors due to mechanical irregularities usually have a repeatable effect. A correction factor varying with the position along the line can be derived. The initial determination is lengthy but the result is a multiplying factor that can be tabulated.

621.317.733 : 621.392.43.029.62 **2837**

A V.H.F. Match Meter.—P. G. Sulzer. (*TV Engng, N.Y.*, July 1950, Vol. 1, No. 7, pp. 4–6.) The meter includes two bridges, and when connected between a low-power r.f. source (10–250 Mc/s) and an aerial or transmission line it indicates the magnitude of the reflection coefficient. One bridge is used for unbalanced systems, the other for balanced systems, the reference impedances being respectively 52 Ω and 300 Ω. The voltmeters reading the input and null voltages consist of crystal diodes with a switched d.c. microammeter. Calibration is effected either by comparison with a voltmeter of known accuracy or by connecting selected h.f. resistors across the test terminals.

621.317.755 : 621.396.645.35 2838

D.C. Amplifier Techniques in Oscillography.—M. Maron. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 11–16.) Design problems are discussed, and a description is given of a d.c. amplifier, developed as a signal amplifier for a c.r.o. Auxiliary circuits, including timebases, are described. Typical applications of the d.c. amplifier in oscillography are outlined.

621.317.763.029.64 : 621.396.611.4 2839

A 10-cm Mechanically Swept Spectrometer.—P. Andrews. (*Proc. Instn elect. Engrs*, Part III, July 1950, Vol. 97, No. 48, pp. 260–264.) Discussion on 2855 of 1949. An instrument for the same frequency, but with an electronic sweep system, is described by P. Bramham.

621.317.79 : 621.3.018.78† 2840

An Intermodulation Analyzer for Audio Systems.—R. S. Fine. (*Audio Engng, N.Y.*, July 1950, Vol. 34, No. 7, pp. 11–13 & 43.) A description, with detailed circuit diagram, of an instrument for measurement of intermodulation distortion. It is particularly useful for assessing the quality of amplifiers and gramophone pickups.

621.317.79 : 621.396.67 2841

The Electronically Driven Ripple-Tank as an Aid to Phase-Front Visualization.—A. H. Schooley. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 303–314.) A detailed account of equipment noted in 1979 of August, with numerous photographs of typical patterns.

621.317.799† : 621.397.5 2842

Inexpensive Picture Generator.—J. R. Popkin-Clurman. (*Electronics*, Aug. 1950, Vol. 23, No. 8, pp. 102–106.) Light from the raster of a television receiver is transmitted through a transparent test pattern and picked up by a multiplier photocell whose output is amplified and corrected for c.r. tube phosphor decay. Video phase-splitting allows positive or negative transparencies to be used. Blanking pulses are added in a mixer whose output is clipped and provides the composite video test-pattern signals, which are suitable for feeding the video section of a television receiver if synchronizing arrangements are available. A separate sweep circuit for providing raster and blanking pulses is described, with detailed diagrams.

621.396.662.029.64 2843

Microwave Attenuators for Powers up to 1 000 Watts.—H. J. Carlin & E. N. Torgow. (*Proc. Inst. Radio Engrs*, July 1950, Vol. 38, No. 7, pp. 777–780.) A broad-band attenuator is described which reduces input powers by a fixed ratio to a low level measurable by a bolometer. The device is a combination of three units: (*a*) a coaxial-line attenuator whose axial conductor penetrates transversely into the main power-carrying coaxial line; this operates on a capacitance-divider principle; (*b*) a metallized-glass coaxial attenuator (348 of 1949) for matching (*a*) to the test line and for equalizing its attenuation with respect to frequency; and (*c*) a tapered-dielectric coaxial load in the main line. Two sets of equipment cover the band 1–10 kMc/s.

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

534.321.9 : 539.32 2844

Ultrasonic Measurement Techniques Applicable to Small Solid Specimens.—H. J. McSkimin. (*J. acoust. Soc. Amer.*, July 1950, Vol. 22, No. 4, pp. 413–418.) A description of techniques for the measurement of velocity of propagation and attenuation by phase-comparison methods, using either longitudinal or transverse waves. One is a resonance technique, using a pulse input and displaying the addition of in-phase multiple reflections from within the specimen. A more precise technique, using c.w. oscillations gated by d.c. pulses, depends on the cancellation of any order of multiple reflection by a delayed signal derived from the input. The phase shifts at reflecting interfaces may be independently determined. Derivations of the principal formulae used are given and the precautions necessary in the use of polystyrene seals and fused-silica supporting rods are described.

534.321.9 : 620.179.1 2845

Ultrasonics and their Use for Non-destructive Testing of Materials.—N. G. Neuweiler. (*Microtecnic, Lausanne*, Jan./Feb. & March/April 1950, Vol. 4, Nos. 1 & 2, pp. 37–44 & 60–66.) Illustrated description of the principles, operation and applications of a flaw detector.

534.321.9 : 621.398 : 535.88 2846

Supersonic Control of a Lantern-Slide Projector.—S. G. Lutz & G. Rand. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 477–481.) Equipment is described which enables a lecturer to operate the slide-changing device on a projector by means of a small ultrasonic whistle concealed in a pocket.

535.214.4 : 535.61-15 2847

The Diaphragm Radiometer.—P. E. Weber. (*Optik*, March 1950, Vol. 6, No. 3, pp. 152–161.) A description is given of an infrared-radiation receiver whose operation is based on the kinetic effect in gases. Thermally modulated radiation is incident on a diaphragm forming one closure of a gas chamber, and the resulting oscillations of the diaphragm produce capacitance variations in one arm of a tuned h.f. bridge. Using a modulation frequency of 100 c/s, radiated power as low as 1.2×10^{-7} W/cm² can be measured, the h.f. voltage delivered being then 10^{-3} V. Greater sensitivity can be attained by exposing the diaphragm to sound of frequency which is a multiple of the modulation frequency.

621.3.087.6 : 534.232 : 534.321.9 2848

Application of Supersonic Energy to High Speed Electronic Recording.—H. J. Dana & J. L. Van Meter. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 473–476.) See 1561 of July.

621.316.72 : 537.533 2849

Automatic Regulation of Thermionic Emission.—W. Steckelmacher & S. van der Meer. (*J. sci. Instrum.*, July 1950, Vol. 27, No. 7, pp. 189–191.) Continuous control for large changes of emission conditions, such as occur in continuously pumped X-ray tubes or ionization vacuum gauges, is effected by using the change of emission current to develop a correction voltage which is applied, after amplification, to a pair of valves whose anode currents govern the heating current for the electron source. A phase-shift network in the feedback chain prevents the oscillations which sometimes occur when controlling massive filaments.

621.317.083.7 2850

Matrix Telemetering System.—N. R. Best. (*Electronics*, Aug. 1950, Vol. 23, No. 8, pp. 82–85.) 30 p.t.m. channels are superimposed on a 1025-Mc/s carrier with peak power of 4 kW. A 10-kc/s oscillator in the transmitting (airborne) unit operates a 32-state counter defining 100-μs time intervals for each channel, and transmits a synchronizing pulse to an oscillator/counter unit in the receiver. The signals in the various channels are displayed as time-positioned dots on a blacked-out c.r. tube trace and are recorded on continuously moving film.

621.317.39 2851

Some Electrical Methods of Measuring Mechanical Quantities.—F. J. Woodcock. (*Proc. Instn elect. Engrs*, Part I, July 1950, Vol. 97, No. 106, pp. 136–149. Discussion, pp. 149–154.) Full paper, including 87 references. Summary noted in 2306 of October.

621.317.39 : 531.717.1 2852

Thickness Gage for Moving Material.—S. V. Hart & I. W. Rozian. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 83–87.) An instrument which records the thickness of any non-magnetic material within the range 0.000 1–1.0 in. and detects deviations of <1 microinch from a standard. The material is inserted between primary and secondary of a split transformer, the output of which is balanced in a bridge circuit against that of a similar unit holding a standard slat. Magnetic materials can be handled by using a pair of differential transformers.

621.317.755 : 621.317.39 2853

Multiple-Channel Cathode-Ray Instrumentation of Non-electrical Quantities.—J. N. Van Scoyoc & G. F. Warnke. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 88–97.) Description of a 24-channel mobile unit using single-beam c.r. tubes whose screen patterns are photographed on continuously moving film.

621.364.55† 2854

Heating by Means of High-Frequency Fields: Part 2—Capacitive Heating.—M. Stel & E. C. Witsenburg. (*Philips tech. Rev.*, Feb. 1950, Vol. 11, No. 8, pp. 232–240.) A formula is derived for the amount of heat generated in unit time in a homogeneous dielectric. Selective heating can be produced when two different dielectrics (e.g. wood and glue) are associated. Industrial applications are discussed. Part 1: 1995 of August.

621.384.6 2855

Principle of an Ion Source for Intense Beams.—C. Cassignol. (*Nature, Lond.*, 5th Aug. 1950, Vol. 166, No. 4214, pp. 233–234.) The principle used is similar to that of Alfvén's trochotron (1205 of 1948), but field modifications are introduced for concentrating positive ions instead of electrons. The extracting electrode is a short cylinder coaxial with the accelerator tube, and is provided with a circumferential slit and maintained negative. An inhomogeneous magnetic field assists in focusing the ions on the slit. Observations on this and on a linear type of source support the theoretical assumptions.

621.384.611.2† : 615.849 2856

Experiments with a 6-MeV Betatron.—K. Gund & W. Paul. (*Nucleonics*, July 1950, Vol. 7, No. 1, pp. 36–45.) An account is given of the development and construction of a betatron in the electromedical laboratory of Siemens-Reiniger-Werke, Erlangen, Germany. Preliminary physical and biological experiments with the equipment are described, including cancer treatment in human beings.

621.384.611.2† 2857

Extraction of the Electron Beam from a 30-MeV Synchrotron.—J. D. Lawson, H. E. Walford & J. H. Aram. (*Nature, Lond.*, 5th Aug. 1950, Vol. 166, No. 4214, pp. 234–235.) Electrons of energy up to 20 MeV have been extracted from the Harwell synchrotron by use of a small shunt coil carrying a pulsed current of up to 6 000 A peak, timed so that the current is a maximum when the electrons enter the shunt. No difficulty is anticipated in applying the method to 30-MeV electrons.

621.387.4† 2858

Scintillation Type Alpha-Particle Detector.—A. S. Goldin, E. R. Rohrer & R. L. Macklin. (*Rev. sci. Instrum.*, June 1950, Vol. 21, No. 6, pp. 554–557.)

621.387.4† 2859

The Theory and Properties of Low-Voltage Radiation Counters.—J. A. Simpson, Jr. (*Rev. sci. Instrum.*, June 1950, Vol. 21, No. 6, pp. 558–568.)

621.387.4† : 548.0 2860

Crystal Counters.—R. Hofstadter. (*Proc. Inst. Radio Engrs*, July 1950, Vol. 38, No. 7, pp. 726–740.) The author's previous survey of this subject (2506 and 2507 of 1949) is extended to cover later developments such as counters using S or Ge crystals.

621.387.424† 2861

Geiger Counter for Civilian-Defense Use.—H. D. LeVine, H. J. DiGiovanni & M. R. Coe. (*Nucleonics*, June 1950, Vol. 6, No. 6, pp. 56–59.) Description of a simple and relatively cheap counter. The necessary h.v. supply is obtained from a vibrator operated by a 3-V flashlight battery.

621.387.424† 2862

A Method of Measuring Spurious Counts in Geiger-Müller Counters.—D. Willard & C. G. Montgomery. (*Rev. sci. Instrum.*, June 1950, Vol. 21, No. 6, pp. 520–521.)

621.387.424† 2863

The Velocity of Propagation of the Discharge in Geiger-Müller Counters.—H. Saltzmann & C. G. Montgomery. (*Rev. sci. Instrum.*, June 1950, Vol. 21, No. 6, pp. 548–549.)

621.387.424† : 531.761 2864

A Direct-Reading Device for Measuring Dead Time and Recovery Time of Geiger Counters.—G. W. Epprecht. (*Helv. phys. Acta*, 20th April 1950, Vol. 23, No. 3, pp. 291–298. In German.) A RC discharge circuit is used to measure the shortest time interval between successive pulses. Some results obtained with the apparatus are shown.

621.396.9 : 526.9 2865

Electronic Contour Mapping.—R. C. Raymond. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 211–216.) A stabilized aircraft with a pencil-beam radar set makes several thousand observations per second on the terrain over which it flies. The data are used to print a contour map. Calculations indicate that with efficient equipment contour maps covering 1 000 square miles could be printed in under an hour.

621.398 2866

The Landis & Gyr Audio-Frequency Telecontrol System.—(*Bull. tech. Suisse romande*, 3rd & 17th June 1950, Vol. 76, Nos. 11 & 12, pp. 146–148 & 162–164.) Description of a system particularly suitable for use on power lines and operating on a frequency of 475 or 725 c/s. A shorter account was noted in 1744 of July.

681.142 : 621.385.832 2867

Coordinate Tubes for Use with Electrostatic Storage Tubes.—R. S. Julian & A. L. Samuel. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 107–122.) The system uses two master tubes which separately control the horizontal and vertical displacements of the electron beams in a bank of slave tubes. Control is effected by servo amplifiers, which locate the proper memory positions from their digital address codes in terms of the mechanical positions of target plates contained within the master tubes. Two different types of tube are described, one for sequential operation, the other for a parallel address system.

621.38 2868

An Introduction to Electronics. [Book Review]—J. Yarwood. Publishers: Chapman & Hall, London, 329 pp., 28s. (*Electrician*, 18th Aug. 1950, Vol. 145, No. 3760, p. 425.) "... for those physics and engineering students ... who need an account of the subject at an intermediate standard ... and also as a guide to lecturers."

621.38 2869

Industrial Electronics and Control. [Book Review]—R. G. Kloeffler. Publishers: Chapman & Hall, London, 1949. 478 pp., 33s. (*Beama J.*, June 1950, Vol. 57, No. 156, pp. 181–182.) "... written not only for the electrical engineer, but also for students of chemical and mechanical engineering who desire a knowledge of industrial electronic applications. The text is descriptive rather than mathematical and the calculus is not employed."

621.38 2870

Electronics, Principles and Applications. [Book Review]—R. R. Wright. Publishers: Ronald Press, New York, 1950. 387 pp., $5.50. (*Electronics*, Aug. 1950, Vol. 23, No. 8, pp. 136, 138.) "A basic course in electronics for nonelectrical engineering students."

PROPAGATION OF WAVES

538.566 2871

On the Existence of a Surface Wave in Dipole Radiation over a Plane Earth.—T. Kahan & G. Eckart. (*Proc. Inst. Radio Engrs*, July 1950, Vol. 38, No. 7, pp. 807–812.) See 2892 of 1949.

621.396.11 2872

Ground-Wave Propagation over an Inhomogeneous Smooth Earth. Part 2 — Experimental Evidence and Practical Implications.—G. Millington & G. A. Isted. (*Proc. Instn elect. Engrs*, Part III, July 1950, Vol. 97, No. 48, pp. 209–217. Discussion, pp. 217–222.) Theoretical considerations of part 1 (1738 of 1949) are reviewed, which predict an increase in field strength on crossing a land/sea boundary. Further experimental results are discussed and found in agreement with theory, although not conclusive. The best conditions for obtaining such an increase in practice are analysed: a wavelength of 4 m is suitable where the distances involved are small, while 100-m wavelength is preferable where attenuation with distance is much greater over land than over sea. Measurements on these wavelengths of field strength along land/sea paths are described; the results show the predicted increase and fit the calculated curves as well as experimental conditions would allow. Some practical implications of the results are discussed, in particular with regard to the siting of transmitters near water, the possibilities of common-frequency working under ground-wave conditions, and the ground-wave coverage of medium- and long-wave navigation aids.

621.396.11 2873

The Beacon Technique as Applied to Oblique-Incidence Ionosphere Propagation.—J. T. de Bettencourt & H. Klemperer. (*Proc. Inst. Radio Engrs*, July 1950, Vol. 38, No. 7, pp. 791–792.) Experiments have been made to identify the propagation paths of pulse signals. An interrogator-responder near Boston transmitted pulses of width 100 μs and repetition rate 20/sec to a transponder in the Caribbean area 2 615 km away. Horizontal rhombic aerials, and transmitters giving 20 kW peak power at 16.08 Mc/s were used at both stations. Photographic records were obtained showing pulse amplitudes against go-and-return time, and go-and-return time against time of day. One-way transmission time is simply calculated from the observations and the path travelled is then identified by means of available charts.

621.396.11 : [551.51 : 535.326 2874

Determination of Modified Index-of-Refraction over the Gulf of Mexico from Radio Data.—Straiton & La-Grone. (*See* 2773.)

621.396.11 : 551.510.535 2875

Ray Paths of Radio Waves in the Ionosphere.—H. Poeverlein. (*Z. angew. Phys.*, April 1950, Vol. 2, No. 4, pp. 152–160.) Graphs are given of the paths of the ordinary and extraordinary rays for a signal of wavelength 80 m both for vertical and oblique incidence on a linearly ionized and on a parabolically ionized layer at a height of 200–300 km. At vertical incidence the ordinary ray is deflected northwards, the extraordinary ray southwards. For small angles of incidence, ray paths are pointed at their apex and the height of reflection is constant. The ray theory may give inaccurate results near the point of reflection. See also 718 of March.

621.396.11 + 621.396.81 : 029.64 2876

Progression of Microwave Radio Scintillations [fluctuations] **at Wind Speed on an Overwater Path.**—A. W. Straiton & H. W. Smith. (*Proc. Inst. Radio Engrs*, July 1950, Vol. 38, No. 7, pp. 825–826.) 3.2-cm radio signals transmitted over a 26.5-mile overwater path were recorded by two receivers (*a*) with a horizontal separation of 65 ft normal to the radio path, (*b*) with a vertical separation of 10 ft. Signal fluctuations progressed at about wind speed between the horizontally separated receivers; a downward but less definite progression was observed for the case of vertical separation. See also 3241 of 1949 and 1483 of June (Straiton et al.).

621.396.81 2877

Propagation of 10-Mc/s Waves over Ranges of 500–1 300 km.—R. G. Sacasa. (*Rev. Telecomunicación, Madrid*, Dec. 1949, Vol. 5, No. 18, pp. 2–8.) Data for 10 Mc/s as optimum working frequency are taken from the diagram previously discussed (2614 of Oct.–b r); these are rearranged in tabular form and considered in detail. Experimental results for reception during November 1949 of Swiss transmissions on 11.865 and 9.665 Mc/s are presented.

621.396.81 2878

Propagation of 12-Mc/s and 15-Mc/s Waves over Ranges of 500–2 400 km.—R. G. Sacasa. (*Rev. Telecomunicación, Madrid*, March 1950, Vol. 5, No. 19, pp. 3–14.) Tabulation and discussion of data obtained from the diagram previously given (2614 of October). Experimental results for 15.17-Mc/s transmissions from Oslo during the period October 1949–February 1950 are presented. Agreement with prediction is very satisfactory.

621.396.812.029.64 2879

Microwave Attenuation Statistics Estimated from Rainfall and Water-Vapor Statistics.—H. E. Bussey. (*Proc. Inst. Radio Engrs*, July 1950, Vol. 38, No. 7, pp. 781–785.) Curves are derived giving predictions of the number of hours per year during which the overall attenuation of a 50-km path and a 1-km path at Washington will exceed various values, for frequencies above 1 kMc/s. The results are obtained by analysing available meteorological data, theoretically derived factors (515 of 1947) being used for converting into radio attenuation values. Extension of the method to other parts of the U.S.A. is discussed.

RECEPTION

621.396.621 : 621.396.619.13 2880

Detector Circuits for Frequency-Modulation Receivers.—C. J. Boers. (*Fernmeldetech. Z.*, Aug. 1950, Vol. 3, No. 8, pp. 296–300.) The disturbing effects of undesired a.m. are examined, and the action of limiters is explained. A subsequent paper is to deal with particular types of discriminator circuit.

621.396.621 : 621.396.619.13 : 621.396.931 2881

Mobile F.M. Broadcast Reception.—R. C. Barritt. (*Electronics*, Aug. 1950, Vol. 23, No. 8, pp. 74–78.) A report of results obtained with various types of aerial and circuit for f.m. broadcast reception in moving vehicles. Increased sensitivity and improved limiting circuits appear to be necessary.

621.396.621 : 621.396.822 2882

Analysis of the Signal/Noise Ratio in U.H.F. Receivers.—E. W. Herold. (*Rev. Telecomunicación, Madrid*, March 1950, Vol. 5, No. 19, pp. 47–60.) A translation from 'Radio at Ultra-High Frequencies', Vol. 2, published by R.C.A. Review. See 2336 of 1942.

621.396.622.015.7 : 621.396.822 2883

Detection of a Pulse Superimposed on Fluctuation Noise.—B. M. Dwork. (*Proc. Inst. Radio Engrs*, July 1950, Vol. 38, No. 7, pp. 771–774.) The frequency response of a linear device giving the maximum value for the ratio between peak amplitude of the signal and the r.m.s. value of the noise at the output is determined analytically for a known pulse superimposed on fluctuation noise with a known spectrum. The result is applied to the case in which the fluctuation noise has a uniform frequency distribution; the optimum network is then physically realizable if the pulse differs from zero for only a finite interval of time. The noise-suppression efficiency of a conventional RC circuit is computed for rectangular and for exponentially decaying pulses.

621.396.662 : [621.396.619.13 + 621.397.62 2884

A New TV-FM Tuner.—C. W. Lytle. (*Tele-Tech*, June 1950, Vol. 9, No. 6, pp. 21–23, 86.) Detailed description of a continuously variable inductive tuner in which tuning is effected by a rotor carrying copper vanes serving as short-circuited turns when brought near the inductor coils. Two sets of coils and vanes are used, one set for the high and the other for the low U.S. television band.

621.396.662.085.3 2885

Hypersensitive Resonance Indicator.—R. L. Ives. (*Electronics*, Aug. 1950, Vol. 23, No. 8, pp. 118–154.) Application of Foster-Seeley and Doppelganger discriminators to resonance indication for weak and fading signals is discussed. Circuit details are given of a complete unit that can be added to any standard superheterodyne receiver.

621.396.81 2886

Propagation of 10-Mc/s Waves over Ranges of 500–1 300 km.—Sacasa. (*See* 2877.)

621.396.81 2887

Propagation of 12-Mc/s and 15-Mc/s Waves over Ranges of 500–2 400 Km.—Sacasa. (*See* 2878.)

STATIONS AND COMMUNICATION SYSTEMS

621.39.001.11 2888

Statistical Theory of Communication.—J. B. Wiesner. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 334–341.) Difficulties in the analysis of communication systems are pointed out and the statistical methods developed by Wiener and Shannon are outlined. The use of statistical concepts to provide a new kind of filtering in the time domain is described. See also 2465 of October (Wiener) and 1649 of 1949 (Shannon).

621.394/.395].44 2889

Carrier-Frequency Technique in Germany, 1935–1945.—G. Hässler. (*Elektrotechnik, Berlin*, June 1948, Vol. 2, No. 6, pp. 161–168.)

621.395 : 621.318.572 2890

Voice-Switched Intercom.—R. H. Baer. (*Electronics*, Aug. 1950, Vol. 23, No. 8, pp. 79–81.) Instead of a talk/listen switch this system uses a 4-terminal repeater with a flip-flop circuit that unblocks gated amplifiers alternately 30 times per sec. Incoming speech signals stop the flip-flop and keep open the desired channel without clipping syllables.

621.395.44 2891

A Twelve-Channel Carrier Telephone System for Use on Cables.—T. B. D. Terroni. (*Stromyer J.*, July 1950, Vol. 7, No. 2, pp. 62–81.) The principal factors which determine the design of 12-channel systems are outlined and the single-modulation method using crystal filters and the group-modulation method using inductor-capacitor filters are discussed. The special features of a group-modulation system are described and performance details are given.

621.396.1 : 519.242 2892

An Extension of Wiener's Theory of Prediction.—Zadeh & Ragazzini. (*See* 2808.)

621.396.3 + 621.396.5] (43) 2893

Survey of the [German] **Overseas Radio Service.**—W. Kronjäger. (*Fernmeldetech. Z.*, Aug. 1950, Vol. 3, No. 8, pp. 265–271.) The different telephony and telegraphy systems are indicated and the organization of the corresponding services is described. Traffic figures are given for 1949.

621.396.61/.62 : 621.396.931 2894

Mobile Radio Unit.—D. Samuelson. (*FM-TV*, July 1950, Vol. 10, No. 7, pp. 18–19, 33.) Design details, with illustrations, of a small transmitter-receiver capable of operating in a single channel without picking up adjacent-channel signals or causing interference with other systems. Transmitter power output is 12 W on 25–50 Mc/s and 10 W on 151–174 Mc/s.

621.396.65 : 621.396.619.11/.13 2895

Modulation Conversion in a Wave Guide.—P. S. Rogell. (*J. appl. Phys.*, July 1950, Vol. 21, No. 7, pp. 629–631.) Theory and design equations are presented for the conversion of a narrow-band f.m. microwave signal into an almost pure a.m. signal within a waveguide of given dimensions. Frequency relations and guide dimensions are arranged so that the f.m. sidebands are shifted with respect to the carrier until they become a.m. sidebands at the guide output. A complex intelligence signal may be transmitted with negligible distortion if it is used for a.m. of an intermediate carrier which is then applied for f.m. of the microwave carrier.

621.396.65.029.64/.64 : 621.397.5 2896

2 000- and 7 000-Mc/s TV Microwave Relays.—E. D. Hilburn. (*TV Engng, N.Y.*, March–June 1950, Vol. 1, Nos. 3–6, pp. 8–11; 18–21; 16, 35; 26.) Relay equipment for transmission of outside programmes to station WMAL-TV is described. The 7-kMc/s equipment is portable and serves for local transmissions over line-of-sight paths up to about 20 miles, while the more powerful 2-kMc/s equipment is used between fixed stations and is effective at much greater ranges. Installation and operation procedures are discussed.

621.396.7 + 621.397.7] (73)(058.7)
621.396.6 : 65(73)(058.7) 2897

Tele-Tech TV-FM-AM Station & Studio Equipment Directory, 1951.—(*Tele-Tech*, June 1950, Vol. 9, No. 6, pp. 37–39...84.) A very comprehensive list of U.S. stations of all types, and of manufacturers of equipment directly or indirectly connected with radio and television.

621.396.712.029.6 : 621.396.619.13(43) 2898

The Technique of U.S.W. Broadcasting.—L. Rohde. (*Fernmeldetech. Z.*, Aug. 1950, Vol. 3, No. 8, pp. 286–292.) Germany is the first European country to introduce u.s.w. f.m. broadcasting. American practice has been studied and full advantage is taken of the possibilities of f.m., viz., high quality, economic use of frequency channels, and reduced interference. Radio links are preferred to cable for all but very short distances. Tetrodes are used for power up to 1 kW, triodes for higher power. The advantages of small automatically controlled transmitters are pointed out, and filter arrangements are described which permit two programmes to be radiated from the same aerial.

621.396.712(43) 2899

Basis of U.S.W. Plan for the U.S. Zone [of Germany].—F. Gutzmann. (*Fernmeldetech. Z.*, Aug. 1950, Vol. 3, No. 8, pp. 276–278.)

621.396.712(43) 2900

The U.S.W. Network of the North-West Germany Broadcasting System.—W. Nestel. (*Fernmeldetech. Z.*, Aug. 1950, Vol. 3, No. 8, pp. 282–285.)

621.396.712(43) 2901

The U.S.W. Network of the South-West [Germany] **Broadcasting System.**—Knöpfel. (*Fernmeldetech. Z.*, Aug. 1950, Vol. 3, No. 8, pp. 279–281.)

SUBSIDIARY APPARATUS

621-526 2902

A Note on the Error Coefficients of a Servo Mechanism.—J. L. Bower. (*J. appl. Phys.*, July 1950, Vol. 21, No. 7, p. 723.)

621.316.722.1 : 621.316.261 2903

A Preservation Rectifier with Electronically Stabilized Charging Voltage.—E. Cassee. (*Philips tech. Rev.*, March 1950, Vol. 11, No. 9, pp. 253–259.) The difference between the charging voltage of an accumulator battery and a constant reference voltage is amplified and used to control the d.c. bias of a transductor in series with the secondary of the transformer feeding the rectifier in the charging equipment. The charging voltage is thereby maintained constant to within 0.5% for mains frequency deviations of 4% or voltage variations of 10%.

621.355.2 + 621.355.8 2904

Military Storage Batteries.—H. Mandel. (*Elect. Engng, N.Y.*, July 1950, Vol. 69, No. 7, pp. 619–621.) Recent developments are described, particularly as regards lead/acid batteries and alkaline batteries with sintered Ni-Cd plates, and obtaining satisfactory performance at very low temperatures.

TELEVISION AND PHOTOTELEGRAPHY

621.397.5 : 621.317.799† 2905

Inexpensive Picture Generator.—Popkin-Clurman. (*See* 2842.)

621.397.5 : 621.396.65 2906

Televising the Boat Race — 1950: The Engineering Problems.—T. H. Bridgewater, R. H. Hammans & S. N. Watson. (*B.B.C. Quart.*, Summer 1950, Vol. 5, No. 2, pp. 107–115.) A detailed account of the system of radio and cable links connecting the equipment on the launch following the race with the Alexandra Palace transmitter.

621.397.5 : 621.396.65.029.63'.64 2907

2 000- and 7 000-Mc/s TV Microwave Relays.—Hilburn. (*See* 2896.)

621.397.5(43) 2908

The Development of Television by the German Post Office.—H. Pressler. (*Fernmeldetech. Z.*, Aug. 1950, Vol. 3, No. 8, pp. 302–308.) A historical review, with extensive bibliography.

621.397.5(43) 2909

Development of Television Technique by the Fernseh G.m.b.H. 1939-1945.—H. Bähring, W. Dillenburger, R.v.Felgel-Farnholz, T. Mulert, F. Rudert & H. Strübig. (*Fernmeldetech. Z.*, Aug. 1950, Vol. 3, No. 8, pp. 308–316.) A review of the most important advances made during the period when normal publication was suspended.

621.397.6 2910

A Film-Dubbing and Review Suite for Television Film Production.—N. F. Chapman. (*B.B.C. Quart.*, Summer 1950, Vol. 5, No. 2, pp. 116–128.) Detailed account of facilities noted in 1539 of June.

621.397.61 : 621.396.619.2 2911

An Analysis of Single and Double Sideband Transmission.—G. E. Hamilton & R. G. Artman. (*TV Engng, N.Y.*, July 1950, Vol. 1, No. 7, pp. 22–24.) A mathematical analysis of d.s.b. and s.s.b. transmission. The attenuation may vary between 6 db and 7 db according to the modulation factor. In d.s.b. operation the detector need respond only to the modulating frequencies, but for s.s.b. transmission a detector with infinite bandwidth is needed to give faithful reproduction.

621.397.61 : 621.396.645.018.424 : 621.3.088.7 2912

The Compensation for Phase Errors in Wide-Band Video Amplifiers.—Brain. (*See* 2752.)

621.397.61 : 621.396.673 2913

1 057-Foot FM-TV Antenna.—(*See* 2722.)

621.397.611.2 2914

A New Image Orthicon.—R. B. Janes, R. E. Johnson & R. R. Handel. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 140–147.) The spectral sensitivity characteristics of image orthicons are discussed and the properties of a new panchromatic high-sensitivity photosurface used in the R.C.A. Type-5820 orthicon are described. This makes television possible under poor lighting conditions. Production problems for the Type-5820 orthicon are briefly discussed. See also 2361 of October.

621.397.621.2 : 621.385.832 2915

The Design and Fabrication of TV Picture Tubes.—Hoagland. (*See* 2943.)

621.397.62 : 621.314.2 2916

A Universal-Application Cathode-Ray Sweep Transformer with Ceramic Iron Core.—C. E. Torsch. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 130–139.) The high-μ, high-Q ceramic iron cores now available enable c.r. tube sweep transformers of high efficiency to be produced. The design of a unit which can be used with any direct-view picture tube is described and typical circuits for use with the unit are given.

621.397.62 + 621.396.619.13] : 621.396.662 2917

A New TV-FM Tuner.—Lytle. (*See* 2884.)

621.397.62 : 621.396.662 2918

Two New Television Tuners.—M. F. Melvin. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 148–160.) Description and performance details of 3-section and 4-section 'spiral' inductuners which are both cheaper and mechanically simpler than previous solenoid designs.

621.397.62 : 621.396.67 2919

An Automatic Built-In Antenna for Television Receivers.—K. Schlesinger. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 292–302.) See 819 of April.

621.397.82 2920

Interference Patterns in Television Pictures.—(*J. Televis. Soc.*, Jan./March 1950, Vol. 6, No. 1, pp. 22–23.) Photographs taken by G.P.O. officials are shown, illustrating the disturbing effects produced on television pictures by different types of interference.

621.397.5 2921

Television Simplified. [Book Review]—M. S. Kiver. *Publishers*: D. Van Nostrand Co., New York, 3rd edn 1950, 556 pp., $6.50. (*Proc. Inst. Radio Engrs*, July 1950, Vol. 38, No. 7, p. 834.) The basic principles of television are explained for the nonmathematical reader. The book deals almost entirely with receivers, and includes a chapter on servicing and installation. New chapters cover intercarrier television sound and colour television.

TRANSMISSION

621.396.61 2922

Lorenz 10-kW U.S.W. Transmitter for F.M. Broadcasting.—G. Brauer. (*Fernmeldetech. Z.*, Aug. 1950, Vol. 3, No. 8, pp. 292–296.) Two of these transmitters have been in operation in Germany since early 1950. An explanation is given of the differences of design called for at frequencies of 87.5–100 Mc/s as compared with transmitters for lower frequencies. The grounded-grid triode power-amplifier valve is described in some detail.

621.396.61 : 621.396.619.13 2923

3000 Watts for State Police.—W. Fingerle, Jr. (*FM-TV*, July 1950, Vol. 10, No. 7, pp. 11–12, 33.) Illustrated description of a f.m. transmitter operating in the range 40–50 Mc/s. Tests indicate that such transmitters give effective state coverage.

621.396.611.21.029.63 : 621.396.931 2924

Crystal Control for Citizens Band.—I. Gottlieb & I. R. Mednick. (*Electronics*, Aug. 1950, Vol. 23, No. 8, pp. 96–98.) Stabilized operation of a war-surplus BC-645 unit on 4.0 Mc/s is effected by the addition of a 2-valve exciter unit and by use of the Type 316-A valve in the BC-645 as a frequency doubler. Frequencies in the band 460–470 Mc/s are derived from crystals with fundamental frequencies between 8.52 Mc/s and 8.70 Mc/s. See also 517 of 1949 (Samuelson).

621.396.619.13 2925

A Versatile Crystal-Controlled Source of Angle Modulation.—J. F. Gordon. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 512–518.) A device is described which produces large deviations and increased modulation sensitivity without loss of transmitter stability; the relatively small number of valves used results in a simple circuit. An experimental unit and details of its performance are also described.

VALVES AND THERMIONICS

621.314.632 2926

G.E.C. Germanium Crystal Rectifiers.—(*Instrum. Practice*, June 1950, Vol. 4, No. 8, pp. 427–428.) Characteristics of four available types are tabulated. All are sealed in glass envelopes and have the metal point cemented to the Ge crystal.

621.314.671 2927

A New Rectifier Tube for Extremely High Power and Voltage Levels.—T. H. Rogers. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 482–492.) The factors which control the design of high-vacuum rectifiers and limit their use for high-current applications are discussed, and new design principles are outlined which have been evolved to raise these limits sufficiently to meet the requirements of devices using high-current high-voltage supplies. New valves described can handle a peak current of 10 A and an inverse voltage of 110 kV.

621.383 2928

Design Features and Some Applications of a New Photocell.—J. H. Crow & V. C. Rideout. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 506–511.) See 1288 of May.

621.383.27† 2929

Photocells with Secondary-Electron Multipliers.—N. Schaetti. (*Helv. phys. Acta*, 3rd Feb. 1950, Vol. 23, Nos. 1/2, pp. 107–120. In German.) The production and properties of various photocathodes and secondary-emission layers are discussed. An 18-stage multiplier with an Sb-Cs photocathode and Ag-Mg coating for the multiplier plates has a sensitivity of 40–60 μA/lumen and a total amplification of 10^{10}–10^{12} with a stage voltage of 200 V.

621.383.4 2930

The Phototransistor.—J. N. Shive. (*Bell Lab. Rec.*, Aug. 1950, Vol. 28, No. 8, pp. 337–342.) The essential element in the device is a wafer of Ge with a spherical dimple ground in one face so that at the centre, where a phosphor-bronze wire of 0.005 in. diameter makes contact, the thickness is about 0.003 in. Operation of the cell depends on the decrease in resistance of the Ge element between its containing ring and the collector wire on exposure to light. For a particular cell operated in series with a 20 kΩ resistor, the calculated current output was about 0.07 mA per millilumen. With fluctuating light the response curve is substantially flat up to 200 kc/s, the highest frequency so far used. The sensitivity is greatest in the spectral region 1.0–1.5 μ. An outline of the theory of the mechanism of photoconductivity is given.

621.385 : 621.396.621 2931

The 6BN6 Gated Beam Tube.—R. Adler. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 408–416.) See 1292 of May.

621.385 : 621.396.621 2932

The 6BN6 Gated Beam Tube.—A. P. Haase. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 417–426.) See 1292 of May (Adler).

621.385.712 2933

New Type of Radiator for High-Power Transmitting Tubes.—O. Schärli. (*Brown Boveri Rev.*, Sept. 1949, Vol. 36, No. 9, pp. 311–315.) A radiator system is described which uses transverse fins consisting of sheet-metal rings separated by spacers and riveted together. Applied to the Type-ATL35-1 valve it can handle an anode dissipation of 46 kW.

621.385.032.216 2934

Conduction Processes in the Oxide-Coated Cathode.—R. Loosjes & H. J. Vink. (*Philips tech. Rev.*, March 1950, Vol. 11, No. 9, pp. 271–278.) Preparation and activation of oxide-coated cathodes is described. Electrons emitted by the coating are replaced by conduction from the metal core and it is suggested that this conduction is due to two processes acting together, electronic conduction of the grains at temperatures $<800°$K and conduction through the electron gas in the pores between the grains at higher temperatures. The lagging of conduction behind emission at temperatures $>1\,000°$K is explained by the effect of the space charge upon the electron density and upon the field in the pores.

621.385.032.24 : 537.52

2935

Experiments on Grid Emission.—A. A. Rusterholz. (*Brown Boveri Rev.*, Sept. 1949, Vol. 36, No. 9, pp. 300–304.) Methods are discussed which result in reduced primary grid emission, particularly in transmitting valves with thoriated-tungsten cathodes. Carburization of the Ta grid wires at a high temperature in CO or CO_2 has been suggested as a means of preventing an increase of grid emission due to activation by Th evaporated from the filament. Experiments with grids carburized in an atmosphere of H_2 saturated with benzene vapour showed, however, that no improvement was effected. Investigations of carburization in CO or CO_2 are being continued.

621.385.032.442 : 621.3.015.4

2936

Hum Characteristics of A.C.-Heated Transmitting Tubes.—F. Atti. (*Brown Boveri Rev.*, Sept. 1949, Vol. 36, No. 9, pp. 305–311.) The hum level in transmitting valves with directly heated tungsten filaments can be reduced very considerably by use of specially designed cathode systems and 3-phase or 6-phase heater supplies. Careful balancing of the phases and accurate alignment of the grid and the filament wires is essential. In the new 200-kW broadcasting transmitter at Beromünster, the hum level in the a.f. output stage, which consists of two class-B triodes with 3-phase heating, is −57 db without feedback, which lowers it further to −61 db.

621.385.2

2937

The High-Frequency Response of Cylindrical Diodes.—E. H. Gamble. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 387–402.) The problem is considered as a quasistationary one and equations are derived for an ideal diode in which the electron paths are normal to the emitting surface. The relations thus obtained are applied to space-charge-limited and temperature-limited operation. Numerical solutions of the nonlinear integral equations were obtained from analogue-computer solutions for the corresponding differential equations. The results indicate the essential correctness of the treatment of the problem.

621.385.3 : 621.315.592† : 621.396.822

2938

Low-Frequency Noise in Transistors.—H. T. Mooers. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 17–22.) The a.f. spectra of both emitter and collector noise in six type-A transistors were investigated. Noise output varies with frequency, but not inversely. Emitter noise does not contribute significantly to the noise output, and this output is independent of d.c. voltage, current and resistance. Good correlation is found between noise power and forward transfer impedance. The noise output may be predicted fairly accurately at any given operating point, for any bandwidth up to 15 kc/s. The lowest input signal strength required to produce a given output signal/noise ratio can also be estimated.

621.385.4 : 621.319.43

2939

Variable-Capacitance Tube for Frequency Control.—R. W. Slinkman. (*Sylvania Technologist*, July 1950, Vol. 3, No. 3, pp. 18–20.) Frequency stabilization of v.h.f. and u.h.f. oscillators in f.m. receivers is effected by means of a tetrode with a bimetallic anode. The curvature of the anode varies with changes of frequency and affects the value of a capacitor within the valve which forms part of the oscillator tank circuit. External series capacitors enable the effective control bandwidth to be adjusted. Tests in a commercial f.m. receiver and in an experimental 600-Mc/s television converter have given promising results.

621.385.832

2940

Beam-Deflection Nonlinear Element.—A. S. Soltes. (*Electronics*, Aug. 1950, Vol. 23, No. 8, pp. 122–178.) A parabolic mask placed between deflector plates and collector enabled a square-law static characteristic to be obtained with an electron beam of rectangular cross-section. Instantaneous squaring of radar-type signals to an accuracy of 2% of full-scale, at an input frequency to the deflector plates of 40 Mc/s, was achieved by this means in the Raytheon tube Type QK-256.

621.385.832

2941

Dimensional Tolerances in Cathode-Ray-Tube Guns.—H. Moss, L. Woodbridge & M. Webb. (*Proc. Instn elect. Engrs*, Part III, July 1950, Vol. 97, No. 48, pp. 277–283.) Preliminary experiments show that cathode tilt in the triode has negligible effect on beam centrality and symmetry. Effects of lateral displacement and tilt of the first anode for various grid/anode spacings are determined experimentally for several types of triode geometry. The astigmatism due to the tilt, displacement and deformation of the final lens elements is also investigated experimentally and an effective type of ion-trap electron gun is described.

621.385.832 : 621.3.087

2942

The Recording Storage Tube.—R. C. Hergenrother & B. C. Gardner. (*Proc. Inst. Radio Engrs*, July 1950, Vol. 38, No. 7, pp. 740–747.) A c.r. tube has a mesh screen coated on the face away from the electron gun with a charge-retaining layer. The potential of an output-signal screen located further along the tube is made negative relative to the cathode, so that when the signal is applied ('written') the beam passes through the mesh screen and is reflected to strike its rear (storage) surface, whereas when the signal is taken off ('read') the beam strikes the output-signal screen which in this case is made more positive than the storage-screen mesh potential, and does not disturb the stored charges. The signal can thus be read 20 000 times without appreciable deterioration and with a decrease in signal level of only a few per cent.

621.385.832 : 621.397.621.2

2943

The Design and Fabrication of TV Picture Tubes.—K. A. Hoagland. (*TV Engng, N.Y.*, March & April 1950, Vol. 1, Nos. 3 & 4, pp. 16–21, 35 & 16–17.) A survey of American manufacturing processes and discussion of present trends in c.r. tube design, with particular attention to beam focusing, the use of slant-field and bent-gun ion traps, metal-cone construction, etc.

621.396.615.14 : 621.385.029.63/.64

2944

The Helix as Resonator for Generating Ultra-High Frequencies.—B. H. van Iperen. (*Philips tech. Rev.*, Feb. 1950, Vol. 11, No. 8, pp. 221–231.) The action of the travelling-wave valve as an amplifier is described briefly and its use as an u.h.f. generator is discussed. The resonances of the helix play an important part in this latter case. A relatively simple method is developed for determining under what conditions oscillations are possible and at what current intensity they begin. Results are given of some experiments which confirm the accuracy of the theory. An experimental valve with gas-concentrated beam is described.

621.396.615.141.2

2945

The Turbator.—F. Lüdi. (*Brown Boveri Rev.*, Sept. 1949, Vol. 36, No. 9, pp. 315–318.) The evolution is reviewed of the Brown Boveri type of magnetron, which comprises a Ba-Sr oxide cathode and a single annular cavity resonator capacitively coupled to the anode segments. The Mo sheet-metal construction of the anode enables an anode dissipation of 200 W to be attained. A glass-enclosed 15-W type is being developed.

621.396.615.141.2 : 621.317.361 **2946**

Measurement of the Space-Charge Resonance Frequencies of a Multicavity Magnetron.—P. Fechner. (*C. R. Acad. Sci., Paris*, 24th July 1950, Vol. 231, No. 4, pp. 270–271.) The magnetron is coupled to a waveguide which is terminated by its characteristic impedance and energized by a klystron generator. Resonance conditions are determined from measurements of the transmission coefficient in the waveguide for different values of magnetic field and anode voltage. The results obtained verify the theory previously given (2678 of October). See also 2680 of October.

621.396.615.142 **2947**

Radial-Beam Velocity-Modulated Microwave Tube.—C. G. Lob & D. F. Holshouser. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 403–407.) The valve consists of a coaxial resonator of length $\lambda/2$, cut in the middle perpendicular to its axis of symmetry so as to constitute two coaxial cavities, each operating in the $\lambda/4$ mode. Surrounding the cut in the resonator is a gun structure with a ring cathode and two focusing electrodes. The action of the valve is similar to that of a two-gap klystron or of a reflex klystron, depending on the operating conditions. Test results on three experimental valves are given. An output of about 3 mW was obtained at a wavelength of 4 cm.

21.396.615.142.2 **2948**

Efficiency of Reflex Oscillators.—W. G. Sheperd. (*Proc. nat. Electronics Conference, Chicago*, 1949, Vol. 5, pp. 500–505.) Analysis of the efficiency and electronic tuning of a reflex oscillator as affected by the use of different modulation coefficients for the outgoing and return transits of the interaction gap.

621.396.645 : 621.396.822 **2949**

Noise Suppression in Triode Amplifiers.—van der Ziel. (*See* 2751.)

MISCELLANEOUS

621.396.7 + 621.397.71] (73)(058.7) **2950**
621.396.6:65 (73) (058.7)

Tele-Tech TV-FM-AM Station & Studio Equipment Directory, 1951.—(*See* 2897.)

658.562 : 519.283 **2951**

Theory of Sampling Inspection Plans.—H. C. Hamaker. (*Philips tech. Rev.*, March 1950, Vol. 11, No. 9, pp. 260–270.) Mathematical principles underlying sampling inspection are discussed. Two parameters for describing an operating characteristic, termed 'point of control' and 'relative slope', are introduced and their relation to sample size and acceptance number is established. Various other parameters in use are reviewed and reasons are given for the choice of the point of control and sample size as a practical set.

621.3 **2952**

Basic Electrical Engineering. [Book Review]—G. F. Corcoran. Publishers: Chapman & Hall, London, 1949, 449 pp., 27s. (*Beama J.*, June 1950, Vol. 57, No. 156, p. 179.) "... the treatment ... is clear, smoothly sequential, succinct but without undue condensation ... It is a most commendable piece of work."

621.396 **2953**

Radio Handbook. [Book Review]—R. L. Dawley (Ed.). Publishers: Editors and Engineers, Santa Barbara, California, 12th edn 1949, 320 pp., $3.25. (*Electronics*, Aug. 1950, Vol. 23, No. 8, pp. 142, 144.) An all-construction edition dealing with transmitter and receiver equipment, including mobile sets. "This edition does not supersede the 11th edition [2680 of 1948], which contains different information and remains current."

621.396/.397 **2954**

Outline of Radio, Television and Radar. [Book Review]—R. S. Elven, T. J. Fielding, R. Molloy, H. E. Penrose, C. A. Quarrington, M. G. Say, R. C. Walker & G. Windred. Publishers: Chemical Publ. Co., Brooklyn, 1950, 688 pp., $12.00. (*Electronics*, Aug. 1950, Vol. 23, No. 8, p. 142.) A book compiled by eight British engineers. "Extensive use of British terminology throughout, along with descriptions and illustrations of British products ... does not impair the usefulness of the book to those seeking to keep in touch with British practice."

Second Group

ACOUSTICS AND AUDIO FREQUENCIES

534.15 2955

The Visualization of Vibratory Phenomena within a Resonant Tube.—C. Chartier, J. Bourot & J. Noël. (*C. R. Acad. Sci., Paris*, 26th June 1950, Vol. 230, No. 26, pp. 2269–2270.) The motions of powder particles within a resonating tube are recorded photographically; observation of changes produced by variation of experimental conditions is facilitated. Formulae are derived giving the deviation of the phase and longitudinal displacement of the powder particles from the values for the gas within the tube. These deviations vary in the same sense as the frequency used and as the size of the particles; faithful results are obtainable with ordinary Al powder at 1 000 c/s. Photographs are reproduced for a tube giving a 32-c/s note, taken with (*a*) continuous and (*b*) interrupted illumination.

534.232 : 534.321.9 2956

Experiments with the Hartmann Acoustic Generator.—L. E. Savory. (*Engineering, Lond.*, 4th & 11th Aug. 1950, Vol. 170, Nos. 4410 & 4411, pp. 99–100 & 136–138.) The air-jet generator has been known for many years but has not been used extensively in industry for generating ultrasonic vibrations on account of its hypersensitiveness in relation to changes of air pressure and of certain interelement spacings. Modifications intended to reduce this instability are described; these include side pads or a short cylinder partially or wholly surrounding the jet somewhere between nozzle and resonator, and a rod inserted along the jet axis. Results are tabulated and discussed.

534.321.9 : 537.228.2 2957

The Generation of Ultrasonic Vibrations by Electrostriction.—H. H. Rust. (*Z. angew. Phys.*, July 1950, Vol. 2, No. 7, pp. 293–294.) Falkenhagen's method (1843 of 1949) is discussed and compared with much earlier work by Langevin.

534.6 : 621.395.623.7 2958

Practical Applications of Acoustic Measurements on Receivers.—A. Moles. (*T.S.F. pour Tous*, June 1950, Vol. 26, No. 260, pp. 224–229.) Results of tests in an anechoic chamber are shown by records of the low-frequency, overall and loudspeaker response curves of a receiver; the effect of varying the receiver selectivity and of using different baffles for the loudspeaker are also shown. The back of a receiver with built-in loudspeaker should be perforated so as to introduce a certain amount of acoustic impedance. Placing a receiver near a partition, which acts as a baffle, results in an appreciable improvement of the bass response; otherwise the position of the receiver has little effect.

534.75 : 534.321.1 2959

Upper Limit of Frequency for Human Hearing.—R. J. Pumphrey. (*Nature, Lond.*, 30th Sept. 1950, Vol. 166, No. 4222, p. 571.) Experimental evidence that the sensory elements at the basal end of the cochlea are competent to respond to sounds of frequency up to 100 kc/s, and that the failure of the normal ear to respond to air-borne sounds of frequency above 20 kc/s is due wholly to the failure of the middle ear to transmit such frequencies. The apparent pitch associated with high-frequency sounds was that of the highest tone audible by air conduction, no increase of pitch being observed above about 15 kc/s.

534.78 : 534.843.5 2960

General Theory of Intelligibility within Rooms.—T. Korn. (*Ann. Télécommun.*, Aug./Sept. 1950, Vol. 5, Nos. 8/9, pp. 316–320.) Reverberation time is not the only important factor governing intelligibility; the effect of the direct sound is another factor of major importance. A method is given for calculating the articulation index anywhere in a room from the values of reverberation time, total absorption and distance from the sound source. The calculated results agree with classical experimental data. The direct sound can be reinforced by architectural or electronic devices.

534.84 : 061.3 2961

Symposium on Architectural Acoustics, Marseilles, 11th-17th April 1950.—P. Chavasse. (*Ann. Télécommun.*, July 1950, Vol. 5, No. 7, pp. 255–258.) A summarized report of the proceedings, with a list of the papers presented.

534.844.1 2962

Measurement of Reverberation Times of Studios of the Radiodiffusion Française.—J. Pujolle & J. Boisard. (*Ann. Télécommun.*, Aug./Sept. 1950, Vol. 5, Nos. 8/9, pp. 307–315.) Apparatus and method are described and degree of accuracy assessed.

534.844.3 2963

A Contribution to the Study of Reverberation.—A. C. Raes. (*Ann. Télécommun.*, July 1950, Vol. 5, No. 7, pp. 259–265.) Paper presented at the International Symposium on Architectural Acoustics, Marseilles, 1950. The relation between the reverberation time of an auditorium and the quality of the sound heard is discussed in the light of R. B. Watson's conception of reverberation modulation. Oscillographically recorded results of experiments made with pure-tone sound sources indicate that the frequency of such modulation may attain the order of 250 c/s, with associated amplitude reductions of 10–18 db.

621.3.018.78† : 621.395.613.3 2964

The Recording of Nonlinear Distortion.—A. Bressi & G. G. Sacerdote. (*Alta Frequenza*, April 1950, Vol. 19, No. 2, pp. 86–92. In Italian, with English, French and German summaries.) The determination of nonlinear distortion is of particular importance in relation to carbon microphones. A method is described for automatically recording the magnitude of this distortion as a function of the applied acoustic pressure at any frequency.

621.395.61/.62 2965

The Constants of Magnetostrictive, Electrostrictive and Piezoelectric Electroacoustic Transducers.—U. John. (*Arch. elekt. Übertragung*, April 1950, Vol. 4, No. 4, pp. 139–145.) From a mathematical treatment of the dynamics of the magnetostriction process an expression is derived for the conversion factor; this is independent of the measurement system used and takes account of the permeability and elastic modulus, and also the magnetostriction factor. A table shows the four different forms of the fundamental dynamic equation, the expressions for their constants and the electromagnetic equivalents. Each group of associated constants can be interpreted as a matrix of a linear quadripole and can be referred to the corresponding groups for the electrostrictive and piezoelectric processes.

621.395.61/.62 2966

The Electrical and Acoustical Impedances and Equivalent Circuits of Electroacoustic Transducers.—F. A. Fischer. (*Arch. elekt. Übertragung*, May 1950, Vol. 4, No. 5, pp. 189–195.) Three basic types of transducer are considered: (*a*) electrically excited, (*b*) magnetically excited, (*c*) electrodynamic. The piezoelectric type is to

be discussed later. An expression for complex impedance is derived in each case and the corresponding electrical and mechanical equivalent circuits are deduced.

621.395.61 2967

Directional Microphones with Phase-Shifting Elements.—H. Grosskopf. (*Fernmeldetech. Z.*, July 1950, Vol. 3, No. 7, pp. 248–253.) The problem of designing a microphone with a directivity independent of frequency is considered generally. Artificial phase-shifting elements are introduced to produce the required directional characteristics. These elements should produce phase-shift proportional to frequency; an acoustic bypass is simplest in theory but is too cumbrous in practice. Elements comprising mechanical impedances are therefore preferred; these are studied by means of mechanical networks. Ribbon and capacitor microphones can be adapted in accordance with the principles given; continuously variable directivity can be obtained by combining in appropriate phase the outputs from two microphones having cardioid diagrams.

621.395.61 : 621.395.828 2968

Methods of Preventing Acoustical Feedback.—W. Burck. (*Frequenz*, July 1950, Vol. 4, No. 7, pp. 161–166.) The positioning of microphone and loudspeaker and the use of compensating circuits are reviewed.

621.395.614 2969

Electroacoustic Apparatus with Rochelle-Salt Crystals.—M. Gosewinkel. (*Frequenz*, June 1950, Vol. 4, No. 6, pp. 142–145.) The effect of temperature change on the crystal characteristics is discussed. Loading methods to compensate for this are not generally satisfactory. In crystal generators the total adverse effect is small. In crystal receivers the change in sensitivity with temperature above 23°C is appreciable and renders them unsuitable where constancy of operation is required.

621.395.625.2 2970

Recent Trends in Disk Recording.—P. Gilotaux. (*Onde élect.*, July 1950, Vol. 30, No. 280, pp. 301–308.) A discussion of factors limiting fidelity of reproduction and of the special problems of fine-groove recording.

AERIALS AND TRANSMISSION LINES

621.317.3.029.6 2971

Lines and Circuit Elements for Microwave Measurements.—Schäfer & Honerjäger. (*See* 3088.)

621.392.018.8 2972

The Attenuation of Transient or Periodic Electromagnetic Waves due to Effects in the Dielectric Medium surrounding Transmission Lines.—R. Pélissier. (*C. R. Acad. Sci., Paris*, 26th June 1950, Vol. 230, No. 26, pp. 2272–2274.) An analysis is given of the manner in which the wavefront corresponding to an applied step voltage is deformed by leakage and corona as it progresses along a line. Corona is doubly effective, firstly by increasing the leakage current, and secondly by producing a space charge leading to an apparent increase in the dielectric constant. Its deforming action is greater than that due to skin effect but less than that due to ground return.

621.392.26 † : 621.3.09 2973

Principles and Applications of Waveguide Transmission.—G. C. Southworth. (*Bell Syst. tech. J.*, July 1950, Vol. 29, No. 3, pp. 295–342.) Excerpts from a book of the same title, in preparation. Chapter 6, which gives a descriptive account of transmission in waveguides, is quoted in full.

621.396.67 + 621.396.11 2974

Symposium on Antennas and Propagation, San Diego, California, April 3-4, 1950.—(*Proc. Inst. Radio Engrs*, Aug. 1950, Vol. 38, No. 8, pp. 958–962.) Summaries are given of 38 papers presented at the conference.

621.396.67 2975

A 600-Ohm Multiple-Wire Delta Antenna for Ionosphere Studies.—H. N. Cones, H. V. Cottony & J. M. Watts. (*Bur. Stand. J. Res.*, May 1950, Vol. 44, No. 5, pp. 475–488.) An account of the design and performance of a multiple-wire delta aerial for vertical-incidence ionospheric recorders. The variation of the terminal impedance over the working range (1–25 Mc/s) is displayed graphically. Radiation pattern measurements using scale-model technique are given and comparative records using the delta aerial and an earlier double-W type are reproduced.

621.396.67 2976

Current Distributions on Transmitting and Receiving Antennas.—T. Morita. (*Proc. Inst. Radio Engrs*, Aug. 1950, Vol. 38, No. 8, pp. 898–904.) A method is described for the direct measurement of the amplitude and phase of current and charge distribution along cylindrical aerials. For the transmitting aerial, the distribution measurement is continued into the coaxial feeder, so that a picture of the complete system is obtained. For the receiving aerial, the distribution is found to vary as a function of the terminating load, as predicted by theory.

621.396.671 2977

A Rigorous Calculation of Tubular Dipole Aerials.—H. Zuhrt. (*Frequenz*, June & July 1950, Vol. 4, Nos. 6 & 7, pp. 135–141 & 178–189.) First published in 1944. Cylindrical dipoles of diameter small, but not negligible, compared with λ are considered. A rigorous theory is developed from a solution of the wave equation satisfying rigorous boundary conditions, an image method being used. The theory is applied to the calculation of the input impedance of a relatively thick symmetrical transmitting aerial; results are compared with measurements. The theory is then extended to certain other asymmetrical receiving and transmitting dipole arrangements and their impedances are calculated.

621.396.671 2978

On the Theory of the Straight Aerial.—J. Grosskopf. (*Arch. elekt. Übertragung*, May 1950, Vol. 4, No. 5, pp. 175–180.) An approximate formula for the radiation impedance is obtained by applying the fundamental principles of the Hallén theory (2763 of 1939) based on Maxwell's equations, but avoiding the complicated iterative process for determining the current distribution in the aerial. Calculations from the approximate formula give results in good agreement with experimental values and of accuracy as good as is given by two terms of Schelkunoff's development.

621.396.677 2979

Electromagnetic Field of the Conical Horn.—M. G. Schorr & F. J. Beck, Jr. (*J. appl. Phys.*, Aug. 1950, Vol. 21, No. 8, pp. 795–801.) The radiation from a conical horn is calculated by the assumed-field method. The calculated results agree well with values found experimentally for cones of half-angle up to about 25°. For greater angles the approximations used are inadequate and result in poor agreement with experiment. The theoretical anomalies are discussed.

621.396.677 : 621.392.26† 2980

The Radiation from a Transverse Rectangular Slot in a Circular Cylinder.—S. Silver & W. K. Saunders. (*J. appl. Phys.*, Aug. 1950, Vol. 21, No. 8, pp. 745–749.) Results obtained previously for slots of arbitrary shape (1588 of July) are applied to the special case of a transverse rectangular slot. The principal transverse-plane pattern for such a slot in which the excitation has only a circumferential tangential electric-field component is the same as the pattern generated by an infinite axial slot with the same circumferential excitation. Theoretical and experimental curves are given for the narrow slot of length $\lambda/2$.

621.396.677.012 2981

Survey of Directional Characteristic Curves and Surfaces.—F. Bergtold. (*Frequenz*, May 1950, Vol. 4, No. 5, pp. 114–117.) The general principles of directional radiation as applied to both e.m. and sound waves are outlined and surfaces are discussed which are such that the radius vector for each point of the surface represents the intensity of the radiation in that particular direction from a source at the origin. The intersection of such a surface with any plane passing through the origin gives the radiation polar diagram for that plane. The advantages of a logarithmic scale for the radiation intensity are pointed out. Two abacs based on rectangular-coordinate diagrams enable the directional characteristics of most types of array to be obtained.

CIRCUITS AND CIRCUIT ELEMENTS

549.514.51.001.8 2982

Applications of Quartz Crystals.—Villem. (*See* 3110.)

621.3.012.8 2983

Construction and Critical Review of Circuit Equivalents for Linear A.C. Elements.—E. Samal. (*Frequenz*, April–June 1950, Vol. 4, Nos. 4–6, pp. 81–88, 117–125, 149–151.) The ideal circuit element is one that can be considered to possess only one electrical property (e.g. resistance), the value of which should be independent of frequency, time, temperature, etc. The accurate representation of actual components by means of such ideal elements is considered in detail with numerous examples, using circle diagrams, oscillatory circuits and transducing networks. The effects of eddy currents, ferromagnetic and e.s. phenomena are discussed and also the modifications necessary to the equivalent circuit when such effects are present. When the particular element in question can no longer be represented accurately by simple diagrammatic methods, recourse must be had to the solution of the appropriate Maxwell equations.

621.3.013.78† 2984

Screening in Electrical Communication Apparatus.—K. F. Weinert. (*Funk u. Ton*, July 1950, Vol. 4, No. 7, pp. 358–368.) Study of the effect of screening in and between coupled quadripoles when the coupling is (*a*) galvanic, the circuits having a common resistor, (*b*) capacitive, (*c*) inductive, or (*d*) mixed. Expressions giving the damping due to different types of screen are tabulated. Incorrect earthing arrangements can lead to considerable reduction in the screening effect.

621.3.015.33 2985
621.3.015.7†

Pulses.—Please note that, in this and subsequent issues, the U.D.C. number used will be 621.3.015.7† instead of 621.3.015.33 used hitherto.

621.3.016.352 2986

Stability Criteria.—E. Görk. (*Arch. elekt. Übertragung*, March 1950, Vol. 4, No. 3, pp. 89–96.) Most methods of determining stability conditions are based on the principle of the number of zeros and poles of the function $Z(p)$. In the method described this principle is applied directly. The expression, based on Cauchy's theorem, for the number of zeros when the function is wholly rational or transcendental is integrated in the appropriate half plane to separate the roots; two examples are calculated. Methods of establishing limits for the roots in determining the degree of stability are shown for three values of damping. The Sturm division method and the use of Hurwitz determinants are discussed.

621.3.016.352 : 621.3.012 2987

Stability Testing by means of Closed and Open Circle-Diagrams.—F. Strecker. (*Arch. elekt. Übertragung*, June 1950, Vol. 4, No. 6, pp. 199–206.) Detailed discussion of the physical meaning and practical application of circle-diagram stability criteria.

621.314.22.015.7† 2988

Pulse Transformers.—H. G. Bruijning. (*Commun. News*, April 1950, Vol. 10, No. 4, pp. 126–131.) The requirements which pulse transformers must satisfy are discussed, a design method is described and the advantages resulting from the use of ferroxcube as a core material are considered.

621.314.23 2989

The Use of U/I Cores in Transformers.—W. Nonnenmacher. (*Funk u. Ton*, Aug. 1950, Vol. 4, No. 8, pp. 385–395.) Stampings for standard U/I cores can be obtained by halving E/I laminations, and hence can be produced without waste. Leakage coefficient is independent of core size and is only half that with E laminations. The sensitivity to external magnetic fields is investigated; with laminations stacked alternately the U core is better in this respect than the shell. This advantage is lost when an airgap is used. The apparent width of airgap with the yoke removed is plotted as a function of the measured airgap for U cores and for the I.59 core.

621.314.3† : 536.58 2990

A Direct-Voltage Amplifier as Power Amplifier and Temperature Regulator.—W. Jellinghaus. (*Z. angew. Phys.*, June 1950, Vol. 2, No. 6, pp. 254–261.) Description of a fast-acting regulator comprising a magnetic amplifier controlled by a thermocouple and followed by a circuit in which the amplified voltage is rectified and used to bias negatively a valve whose anode circuit includes premagnetization windings for a second magnetic amplifier supplying the heating element.

621.316.726 : 621.384.611.2† 2991

Frequency Control for the Bevatron Radio-Frequency Voltage.—Riedel. (*See* 3116.)

621.316.89 : 621.385.831 2992

The Negative-Feedback Valve as a Controllable Effective Resistance.—A. Kleint. (*Funk u. Ton*, June 1950, Vol. 4, No. 6, pp. 293–297.) When the negative feedback is such that the alternating voltage at the grid is equal to that at the anode, the a.c. resistance of an amplifier valve is equal to the reciprocal of its slope. Applications of the principle include conductance measurements in parallel resonant circuits, use as a resistor in a phase-shift oscillator, and noise limitation in f.m. receivers. Basic circuits are shown.

621.318.4 : 621-05 2993

Universal Coil Winding.—E. Watkinson. (*Proc. Instn Radio Engrs, Aust.*, July 1950, Vol. 11, No. 7, pp. 179–186.) A typical coil-winding machine and the winding patterns derived from it are described. The factors which influence the choice of the coil-winding gear ratio are explained and analysed. The results are presented in a form suitable for slide-rule computation.

621.319.55 : 517.93 2994

A Note on a Generalized van der Pol Equation.—W. Nijenhuis. (*Philips Res. Rep.*, Dec. 1949, Vol. 4, No. 6, pp. 401–406.) The asymmetrical van der Pol equation, $\ddot{v} - \epsilon(1 - 2\beta v - 3v^2)\dot{v} + v = 0$, is shown to be equivalent to the classical van der Pol equation ($\beta = 0$) with a constant on the right-hand side. For large values of ϵ and β a simple approximation for the limit cycle is found from which it follows that the ratio of the maximum positive and negative values of $v(t)$ cannot exceed 3 : 1.

621.319.55 : 517.93 2995

On the Theory of Relaxation Oscillations.—W. Taeger. (*Funk u. Ton*, June & July 1950, Vol. 4, Nos. 6 & 7, pp. 298–307 & 341–346.) The second-order equation applicable to an oscillatory circuit with periodically varying resistance is reduced to Mathieu's differential

form and solutions are obtained for values of damping coefficient (*a*) <1 and (*b*) >1. The theory is then applied to the case of a neon-lamp relaxation circuit and formulae for the frequency and amplitude of oscillations are derived.

621.385.2/.4 : 621.315.59 2996

Transistor and Transistron.—Adam. (*See* 3210.)

621.392.52 2997

Tchebycheff Functions.—W. Klein. (*Arch. Elektrotech.*, 1950, Vol. 39, No. 10, pp. 647–657.) The Tchebycheff functions of real arguments used in filter theory are presented in five different ways. An extension to complex arguments is made to take into account losses in the circuit elements. A capacitively coupled band-pass filter is discussed as an example of the application of functions with complex arguments.

621.392.52 2998

Use of a Template Method for the Design of Filters.—A. Fromageot & M. A. Lalande. (*Ann. Télécommun.*, Aug./Sept. 1950, Vol. 5, Nos. 8/9, pp. 277–290.) The methods described are based on that of Rumpelt (729 of 1943) and apply to lattice filters with opposite arms consisting of identical two-poles. The critical frequencies of the two-poles in the pass band depend on the image-transfer coefficient, in the stop band they depend on the image impedance. The image-transfer coefficient is defined by the required attenuation, the image impedance by its mean value and the permissible variation within the pass band. Some examples are given using piezoelectric crystals as circuit elements. See also 842 of April.

621.392.52 : 621.3.012.8 2999

The Relation between Recurrent Networks and Radio Filter Circuits.—W. Klein. (*Funk u. Ton*, June 1950, Vol. 4, No. 6, pp. 273–281.) The theory of the recurrent network is discussed by analysing a basic filter consisting of a branched circuit in which series resistance and shunt conductance are equivalent, the former comprising ohmic resistance and pure reactance in series, the latter a parallel combination of ohmic conductance and pure susceptance. On the basis of equivalent circuits having the same transmission factor, a short-circuit tuned, reactively coupled radio filter is developed from the basic network. Bandwidth here is necessarily restricted since all series impedances in the filter are considered as frequency-independent reactances. For transmission over a relatively wide band the basic type of network is required.

621.392.52 : 621.396.662 3000

A New High-Frequency Filter with Band-Pass-Filter Properties.—F. Benz. (*Öst. Z. Telegr. Teleph. Funk Fernsehtech.*, May/June 1950, Vol. 4, Nos. 5/6, pp. 70–75.) The filter described comprises two parallel-resonant circuits detuned from each other by a small amount. The input voltage is shared between them so that a differential output is obtained across the two circuits in series. Circle diagrams, frequency-response curves and phase characteristics are plotted, and performance compared with that of the common type of filter circuit. Applications are discussed; in general the arrangement can be substituted for ordinary resonant-circuit couplings. Symmetry of the frequency-response curve is inherent in the design.

621.396.611.1 3001

A Resonant Circuit with a Time-Variant Resistive Element.—P. Bura & D. M. Tombs. (*Nature, Lond.*, 16th Sept. 1950, Vol. 166, No. 4220, pp. 483–484.) Two phenomena have been observed: (*a*) multiple resonance, in a circuit tuned to f_0 (6 kc/s) the resistive element was varied at f_g (50 c/s) and the voltage across the main capacitance showed peaks at $f_0 + nf_g$, where $n = 1, 2, 3 \ldots$; (*b*) parametrically excited oscillations; when f_g was about $2f_0$ and the effective resistance became negative during part of the cycle, oscillations at $f_g/2$ occurred over a range of frequencies near f_0. This range is limited by sharp cut-off of the self-oscillation, which suggests the use of the device as a filter, the bandwidth being readily controlled. Calculations, based on a theory briefly indicated, are in good agreement with experimental results.

621.396.615 3002

Electron Transit Time in Negative-Grid Oscillator.—S. K. Chatterjee & B. V. Sreekantan. (*Indian J. Phys.*, March 1949, Vol. 23, No. 3, pp. 119–130.) Expressions are derived for cathode/grid and grid/anode electron transit times for a triode operating as a class-C oscillator, taking account of the a.c. voltages on anode and grid and also of the grid bias. Numerical results are given for various valves.

621.396.615 3003

The Limiting Frequency of an Oscillator Triode.—K. Rodenhuis. (*Philips Res. Rep.*, Feb. 1950, Vol. 5, No. 1, pp. 46–77.) The triode is considered as a quadripole. General conditions, which the quadripole coefficients must satisfy in order that the quadripole may be able to deliver power to an external circuit, are derived; these are identified with the oscillation conditions for a triode. The relations between the quadripole coefficients of a triode on the one hand, and the properties of the electron current, the series resistances in the electrode leads, the resistance of the emissive coating, and the dielectric losses, on the other hand, are established and discussed. When the theory is applied to the u.s.w. oscillator triode Type EC81, the calculated limiting frequency is 15% above the observed value. This discrepancy is attributed to approximations in the theory. The experimental determination of the limiting frequency is briefly described.

621.396.615.14 + 621.396.645] : 621.385.029.63/.64 3004

Amplification and Generation of Microwave Oscillations with Travelling-Wave Valves.—H. Schnitger. (*Funk u. Ton*, July 1950, Vol. 4, No. 7, pp. 347–354.)

621.396.615.141.2 3005

Development of the Turbator for Radio-Relay Equipment.—F. Lüdi. (*Brown Boveri Rev.*, Dec. 1949, Vol. 36, No. 12, pp. 405–409.)

621.396.615.17 3006

Discussion of an Asymmetrical Multivibrator Circuit.—J. Blok & C. C. Jonker. (*Physica, 's Grav.*, April 1950, Vol. 16, No. 4, pp. 381–390. In English.) The properties of asymmetrical multivibrator circuits are discussed by the method used by Andronow (1648 of July) for the symmetrical multivibrator. The method is extended to take account of grid currents. The operation of such circuits as discriminators is examined and the resolving time is estimated.

621.396.619 : 538.632 3007

Possible Modulators Based on the Hall Effect.—Y. Rocard. (*Rev. sci., Paris*, Oct./Dec. 1949, Vol. 87, No. 3304, p. 212.) The circuit described is intended for amplifying weak d.c. The Hall effect is produced in a thin Ge plate by means of an auxiliary alternating current and an alternating magnetic field whose strength is controlled by the d.c. to be amplified. Voltage amplification of some thousandfold is obtainable.

621.396.645 3008

Improving Differential-Amplifier Rejection Ratios.—R. McFee. (*Rev. sci. Instrum.*, Aug. 1950, Vol. 21, No. 8, pp. 770–771.) Modifications are suggested to two standard differential-amplifier circuits which effect fifty-fold improvements in rejection ratios. Where

the input potentials are applied to the grids of a pair of similar triodes having *a common cathode* resistor, R_K, the modification consists in connecting a resistor equal in value to R_K across the output triode, from cathode to anode. In the symmetrical amplifier in which the output is taken from both anodes of the pair of triodes, the modification consists in connecting equal resistors across each of the two valves, from anode to the high-potential end of the cathode resistor, the output being taken from suitable symmetrical tapping points.

621.396.645 **3009**

Stagger-Tuned Intermediate-Frequency Amplifier Design.—A. B. Thomas. (*J. Instn Engrs Aust.*, June 1950, Vol. 22, No. 6, pp. 141–148.) Charts are given for facilitating selection of the most suitable type of inter-stage coupling for any particular purpose, and for deciding the frequency and damping of each stage in a stagger-tuned unit. A method is given for extracting the response curve of any stage, and a simple lining-up procedure is described which can be applied to staggered triples. Reference is made to a radar unit recently constructed, with a mid-band gain of 100 db and a bandwidth of 12.5 Mc/s centred at 70 Mc/s. This receiver proved to be stable and easy to handle and duplicate.

621.396.645 : 621.316.078 **3010**

Automatic Stabilization of Amplifier Gain.—A. W. Keen. (*J. Brit. Instn Radio Engrs*, June 1950, Vol. 10, No. 6, pp. 198–207.) "The conventional method of measuring the voltage gain of an amplifier by equating it with the loss introduced by a calibrated attenuator is adapted to provide a continuous and automatic method of accurately defining and maintaining constant amplifier gain. The resultant arrangements are all forms of negative feedback systems and are characterized by high loop gain and the use of a precision attenuator in the β network. Two types are distinguished according to whether the error signal representing the discrepancy between the input and attenuated output signals is made self-cancelling by being fed back into the amplifier as in conventional feedback amplifiers, or used to control the gain of one or more of the amplifying valves, as in a.g.c. systems. Appropriate circuit technique is indicated and suitable applications of the method are briefly described."

621.396.645.37 **3011**

Selective Amplification by means of RC Feedback Networks.—M. Picchi. (*Alta Frequenza*, April 1950, Vol. 19, No. 2, pp. 59–85. In Italian, with English, French and German summaries.) General expressions are derived for the resonance frequency and resonance coefficient of a selective amplifier. Three particular amplifier circuits are discussed in which the Scott parallel-T quadripole, the Wien-Robinson bridge, and certain phase-shift quadripoles are used as feedback networks.

621.396.645.371 **3012**

A Note on the Maximum Feedback Obtainable in an Amplifier of the Cathode-Feedback Type.—J. te Winkel. (*Philips Res. Rep.*, Feb. 1950, Vol. 5, No. 1, pp. 1–5.) The total feedback on the last valve in a feedback amplifier is calculated for the case where the feedback voltage is derived from the cathode load impedance of the last valve. The total feedback is invariably less than the product of individual valve feedback and feedback around the main loop, and has an upper limit dependent only on frequency and on the ratio of transconductance to input capacitance of the last valve.

621.396.645.371 : 523.165 **3013**

Linear Preamplifier for Driving a Long Coaxial Cable.—L. G. Lewis, J. G. Robinson & J. Toll. (*Rev. sci. Instrum.*, July 1950, Vol. 21, No. 7, pp. 593–596.) Linearity and long-term stability under severe weather conditions have been achieved by using negative feedback. The particular application is to an exposed particle-detector system linked by a 100-ft length of cable to the main amplifier.

621.396.665 : 621.396.645.371 **3014**

Correction and Clarification of "Automatic Volume Control as a Feedback Problem".—B. M. Oliver. (*Proc. Inst. Radio Engrs*, Aug. 1950, Vol. 38, No. 8, p. 904.) Correction to paper abstracted in 2501 of 1948.

621.397.645 **3015**

Television Intermediate-Frequency Amplifiers.—Coenraets. (*See* 3191.)

621.392.52 **3016**

Siebschaltungen mit Schwingkristallen (Crystal Filter Circuits). (Book Review)—W. Herzog. Publishers: Peterschsche Verlagsbuchhandlung, Wiesbaden, 1949. 301 pp., 45 DM. (*Fernmeldetech. Z.*, July 1950, Vol. 3, No. 7, pp. 256–257.) The author has brought together in this comprehensive and clearly presented work the material available on the subject. General laws and principles of filter design are given, and basic properties of crystals are explained by means of equivalent circuits. Examples are calculated, and sections are devoted to the adjustment, measurement and temperature dependence of the filters. The text is arranged so that for designing any particular type of filter only the relevant section has to be consulted.

621.396.611.1 + 621.385.029.6 **3017**

Technique des ondes très courtes et ultracourtes: Tome I — Circuits oscillants et tubes à vide. (Book Review)—L. Liot. Publishers: Dunod, Paris, 1949. 253 pp., 780 fr. (*Alta Frequenza*, April 1950, Vol. 19, No. 2, pp. 110–111.) Essentially a practical book, useful both as an introduction to the subject and for reference.

GENERAL PHYSICS

530.112 **3018**

Matter, a Mode of Motion.—R. V. L. Hartley. (*Bell Syst. tech. J.*, July 1950, Vol. 29, No. 3, pp. 350–368.) "Both the relativistic and wave mechanical properties of particles appear to be consistent with a picture in which particles are represented by localized oscillatory disturbances in a mechanical ether of the MacCullagh-Kelvin type. Gyrostatic forces impart to such a medium an elasticity to rotation, such that, for very small velocities, its approximate equations are identical with those of Maxwell for free space. The important results, however, follow from the inherent nonlinearity of the complete equations and the time dependence of the elasticity associated with finite displacements. These lead to reflections which permit of a wave of finite energy remaining localized. Because of the nonlinearity, the amplitude and energy of a stable mode, as well as the frequency, are determined by the constants of the medium. Such a stable mode is capable of translational motion and so is suitable to represent a particle. The mass assigned to it is derived from its energy by the relativity relation. While this mass is dimensionally the same as that of the medium it is differently related to the energy and so need not conform to the classical laws which the latter is assumed to obey. Exchanges of energy between particles and between a particle and radiation involve frequency changes as in the quantum theory. The experimental detection of a uniform velocity relative to the medium is not to be expected. Besides providing a new approach to the problems of particle mechanics, the theory offers the prospect of incorporating the present pictures into a more comprehensive one, with a material reduction in the number and complexity of the independent assumptions." See also 3019 below.

531.112 : 535.312 3019

The Reflection of Diverging Waves by a Gyrostatic Medium.—R. V. L. Hartley. (*Bell Syst. tech. J.*, July 1950, Vol. 29, No. 3, pp. 369–389.) "This paper furnishes the basis for a companion one [3018 above], which discusses the possibility of describing material particles as localized oscillatory disturbances in a mechanical medium. If a medium is to support such disturbances it must reflect a part of the energy of a diverging spherical wave. It is here shown that this property is possessed by a medium, such as that proposed by Kelvin, in which the elastic forces are of gyrostatic origin. This is due to the fact that, for a small constant angular displacement of an element of this medium, the restoring torque, instead of being constant, decreases progressively with time."

535.8 3020

On the Design of Wide-Angle Schmidt Optical Systems.—E. M. Wormser. (*J. opt. Soc. Amer.*, July 1950, Vol. 40, No. 7, pp. 412–415.) "A method of balancing the optical aberrations over a wide angular field of a Schmidt optical system is described."

537.122 : 538.691 3021

Electron Motion in Alternating Magnetic Fields.—A. Kneschke. (*Arch. elekt. Übertragung*, May 1950, Vol. 4, No. 5, pp. 165–172.) The differential equation expressing the motion is integrated completely. The geometric and kinematic characteristics of the electron paths are investigated and related to curves whose curvature is a periodic function of arc length. Certain special cases of the general trajectory are analysed in detail and shown graphically.

537.226 3022

Equivalence of Temperature and Frequency in Dielectric Measurements.—K. H. Stark. (*Nature, Lond.*, 9th Sept. 1950, Vol. 166, No. 4219, p. 436.) The variation of the complex dielectric constant as a function of frequency is represented by a circular arc. Experiments with two widely different dielectrics yielded circular arcs also for variation of complex dielectric constant as a function of temperature. Equivalence of temperature and frequency for dielectrics with a wide distribution of relaxation times is hence established, but no theoretical explanation is known.

537.311.31 3023

The Bloch Integral Equation and Electrical Conductivity.—P. Rhodes. (*Proc. roy. Soc. A*, 22nd Aug. 1950, Vol. 202, No. 1071, pp. 466–484.) An extension of the detailed development of the Bloch treatment of the temperature variation of conductivity to cover a wider temperature range. Theoretical and experimental results are in good general agreement.

537.311.33 3024

Thermal Equilibrium in Neutron-Irradiated Semiconductors.—J. H. Crawford, Jr. & K. Lark-Horovitz. (*Phys. Rev.*, 1st Sept. 1950, Vol. 79, No. 5, pp. 889–890.) Analysis of conductivity/irradiation curves of Ge semiconductors exposed to neutron flux shows the experimental minimum conductivity to be much lower than anticipated. Redetermination of the product of electron and hole densities from Hall-effect measurements gives a value of 3.6×10^{26} at 300°K, which is about one tenth of the value previously found and which yields a much better estimate of minimum conductivity. Measurements are made with the material in the pile, where photo-effects play an important part.

537.311.33 : 538.632 3025

Temperature Dependence of the Energy Gap in Germanium from Conductivity and Hall Data.—V. A. Johnson & H. Y. Fan. (*Phys. Rev.*, 1st Sept. 1950, Vol. 79, No. 5, p. 899.) The data are for the temperature range 500°K to 850°K. If the energy gap between the full and conduction bands is expressed by the relation $E_g = E_{g_0} + (\partial E_g/\partial T)T$, E_{g_0} is determined as 0.73 eV and $\partial E_g/\partial T$ as constant at $(-1.1 \pm 0.1) \times 10^{-4}$ eV/°K, assuming $m_n m_h = m_e^2$, where m_n, m_h, m_e are the effective electron and hole masses and free-electron mass respectively.

537.311.33 : 538.632 3026

On the Theory of the Hall Effect for the case of Composite Conductors in an Alternating Electric Field.—H. Welker. (*Onde élect.*, July 1950, Vol. 30, No. 280, pp. 309–316.) In the case considered, two types of moving charge carrier are present; large displacements of charge perpendicular to the primary current occur. These displacements have appreciable relaxation times, whose magnitudes are examined by substituting a.c. for d.c. primary current. The value of the Hall voltage then depends on the frequency of the a.c. Results are given for various composite conductors, including electrolytes, semiconductors and polyvalent metals. Formulae for determining particle concentrations and mobilities are derived and the possibilities of experimental verification are discussed.

537.525 : 534.01 3027

Effects of Plasma Boundaries in Plasma Oscillations.—D. Bohm & E. P. Gross. (*Phys. Rev.*, 15th Sept. 1950, Vol. 79, No. 6, pp. 992–1001.) An electron taking part in a travelling plasma oscillation will be reflected at a sheath of infinitesimal thickness with velocity appropriate to the oscillation travelling in the reverse direction, so that standing waves are built up without loss at the sheath. This approach is extended to sheaths for which a finite time of penetration is necessary before reflection occurs, and also to the case of reflection at metallic electrodes. In both cases expressions are derived for the damping. For low-pressure discharges, the damping resulting from imperfect reflection from electrode sheaths may be comparable with collision damping, but the damping due to conducting electrodes is unimportant.

The excitation of the plasma by sharp beams is considered and expressions are derived for the energy transfer of a beam to waves of growing and of stationary amplitude. Beams should only excite oscillations when a regular geometry exists. With irregular geometry, bunching pulses are to be expected. A detailed analysis of the bunching is given.

537.533.8 3028

Measurement of Secondary Electron Emission from Dielectric Surfaces.—H. L. Heydt. (*Rev. sci. Instrum.*, July 1950, Vol. 21, No. 7, pp. 639–642.) The method described involves bombarding the metal-backed dielectric surface with primary electrons so as to produce a secondary-emission ratio greater than unity and hence a surface potential of known value.

538.221 3029

Departure from the Rayleigh Law of the Magnetization of a Ferromagnetic Material.—H. D. Bush. (*Nature, Lond.*, 2nd Sept. 1950, Vol. 166, No. 4218, pp. 401–402.) An interim report of experimental investigations.

539.233 : 535.215 3030

Photoadsorption of a Thin Layer of Barium.—C. Biguenet. (*Le Vide*, July/Sept. 1950, Vol. 5, Nos. 28/29, pp. 831–836.) Experiments are described which confirm that light produces large variations of the contact difference of potential between an oxide cathode and a tungsten-filament collector electrode; the experiments show also that the effect is not due to photoemission. A possible explanation is that the barium adsorbed on the tungsten filament is ionized by the light, causing a change in the electron affinity of this electrode.

548.0 : 537 3031

Scattering of Electrons in Crystals in the Presence of Large Electric Fields.—J. Bardeen & W. Shockley. (*Phys. Rev.*, 1st Oct. 1950, Vol. 80, No. 1, pp. 69–71.) "By the calculation of transitions between states appropriate to electrons moving in a large uniform electric field superimposed on a periodic crystal field, it is shown that the probabilities of scattering by lattice vibrations or imperfections are independent of the uniform field and are given by the usual expressions derived for zero field. This justified the procedure of treating acceleration by the field and scattering as independent processes."

548.0 : 537 3032

Deformation Potentials and Mobilities in Non-Polar Crystals.—J. Bardeen & W. Shockley. (*Phys. Rev.*, 1st Oct. 1950, Vol. 80, No. 1, pp. 72–80.) "The method of effective mass, extended to apply to gradual shifts in energy bands resulting from deformations of the crystal lattice, is used to estimate the interaction between electrons of thermal energy and the acoustical modes of vibration. The mobilities of electrons and holes are thus related to the shifts of the conduction and valence-bond (filled) bands, respectively, associated with dilations of longitudinal waves. The theory is checked by comparison of the sum of the shifts of the conduction and valence-bond bands, as derived from the mobilities, with the shift of the energy gap with dilation. The latter is obtained independently for silicon, germanium and tellurium from one or more of the following: (1) the change in intrinsic conductivity with pressure, (2) the change in resistance of an *n-p* junction with pressure, and (3) the variation of intrinsic concentration with temperature and the thermal expansion coefficient. Higher mobilities of electrons and holes in germanium as compared with silicon are correlated with a small shift of energy gap with dilation."

621.3.013.783† 3033

Generalized Impedance Method Applied to Electromagnetic Field Screening.—G. Bonfiglioli & G. Montalenti. (*Alta Frequenza*, April 1950, Vol. 19, No. 2, pp. 93–105. In Italian, with English, French and German summaries.) Cases are first discussed in which problems of e.m. wave propagation in discontinuous media can be treated by Schelkunoff's method for an infinitely long line. Two special cases are investigated: a spherical-wave generator within a spherical screen and a cylindrical-wave generator within a cylindrical screen. For a screen of small thickness and for a stated relation between screen thickness, conductivity and permeability and generator frequency, frequency ranges may occur within which a copper screen is more efficient than an iron one.

621.384.611.1† 3034

The Theory of Electron Acceleration in the Alternating Magnetic Field.—J. Picht. (*Optik*, Jan.–March 1950, Vol. 6, Nos. 1–3, pp. 40–55, 61–97 & 133–144.) The theory of the betatron (or rheotron) is considered. The analysis is based on the Hertzian vector and avoids the distinction drawn in previous work between the 'guiding' field and the 'accelerating' field, since it is the resultant field that determines the electron motion. The stability of the electron path is investigated and the conditions for stability are given for the case of fields of strengths used in practice. The possibility of focussing electrons emitted in different directions is discussed.

621.396.822 : 621.315.592† 3035

On the Noise Spectra of Semiconductor Noise and of Flicker Effect.—A. van der Ziel. (*Physica, 's Grav.*, April 1950, Vol. 16, No. 4, pp. 359–372. In English.) An explanation is given of the fact that in flicker effect and semiconductor noise the noise intensity is inversely proportional to the frequency over a wide range of frequency. General theorems relating to Fourier analysis of fluctuating quantities are mentioned and it is shown to be impossible for the noise intensity to be inversely proportional to the frequency throughout the interval $0<f<\infty$. Inverse proportionality over a wide range can be obtained if a distribution function of correlation times is introduced. Such a function should be expected from the various mechanisms involved.

The sources of noise in semiconductors are considered; the shot effect discussed by Brillouin, Bernamont and Gisolf (667 of March) is not sufficient to account for all the noise. Other mechanisms such as flicker effect and resistance fluctuations due to movements of foreign atoms or to lattice distortions contribute to give the requisite distribution of correlation times.

Flicker effect is discussed, with particular reference to Macfarlane's theory (4087 of 1947). It is suggested that flicker effect in oxide-coated cathodes may not be primarily due to the surface of the coating, but much more to what happens inside it. In an appendix, Bernamont's and Gisolf's treatment of shot noise are shown to be equivalent.

539 3036

Ions, Electrons and Ionizing Radiations. (Book Review.)—J. A. Crowther. Publishers: Arnold, London, 8th edn 1949, 322 pp., 21s. (*Nature, Lond.*, 26th Aug. 1950, Vol. 166, No. 4217, p. 328.) This new edition of a work which since 1919 has served "as an introduction to the major treatises on atomic physics" retains and brings up to date the account of the main lines of progress.

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.165 : 621.396.645.371 3037

Linear Preamplifier for Driving a Long Coaxial Cable.—Lewis, Robinson & Toll. (*See* 3013.)

523.746 : 621.396.812.5 3038

Results of Statistical Analysis of Fade-Outs.—D. Stranz. (*Arch. elekt. Übertragung*, June 1950, Vol. 4, No. 6, pp. 217–218.) Correlation of sunspot data with 130 cases of total disappearance of radio signals observed during 1948.

523.75 3039

The Solar Flare of November 19, 1949 and Cosmic Rays.—J. Clay & H. F. Jongen. (*Phys. Rev.*, 1st Sept. 1950, Vol. 79, No. 5, pp. 908–909.) Cosmic-ray intensity was recorded using both shielded and unshielded ion chambers. With a normal flare the intensity falls below the quiescent value some few hours after the flare. This flare was abnormal in that there was no difference in cosmic-ray intensity before and after it.

A fade-out of the Noordwijk radio station was noted and also a magnetic disturbance with a maximum range in H of 215γ.

523.854 : 621.396.822 3040

Present-Day Ideas on the R.F. Radiation from the Galaxy.—R. Gallet. (*Rev. sci., Paris*, July/Sept. 1949, Vol. 87, No. 3303, pp. 157–161.) Jansky's theory, that galactic radiation originates in the ionized interstellar gas, and the theory of Pawsey and his co-workers, that this radiation is emitted by the stars, are discussed. The apparent and electronic temperatures of the sources deduced from the observations of various workers are very high, and alternative theories such as that of plasma oscillations are examined. Further fundamental quantitative investigation is necessary before any theory can be finally accepted.

551.5 : 621.396.9 3041

The Temperatures at the Tops of Radar Echoes Associated with Various Cloud Systems.—R. F. Jones. (*Quart. J.R. met. Soc.*, July 1950, Vol. 76, No. 329, pp. 312–330.)

551.5 : 621.396.9 3042

Radar Weather Echoes.—R. F. Jones. (*Met. Mag.*, April–July 1950, Vol. 79, Nos. 934–937, pp. 109–112, 143–145, 170–172 & 198–200.) Some typical examples are given of 10-cm radar echoes obtained over a two-year period, using p.p.i. and height-range equipment. The echoes correspond with most types of weather phenomena observed in the temperate zone. The interpretation of the echoes from warm and cold fronts agrees well with generally accepted theories, but the phenomena of occluded fronts may be more complex and not capable of interpretation by a simple model. A few examples of unusual types of echo are given, with their probable explanations.

551.5 : 621.396.9 3043

Radar Echoes.—J. E. N. Hooper & A. A. Kippax; R. F. Jones. (*Quart. J.R. met. Soc.*, July 1950, Vol. 76, No. 329, pp. 330–336.) Discussion on papers noted in 2221 of October and 3042 above.

551.510.535 3044

Large-Scale Sporadic Movements of the E-Layer of the Ionosphere.—N. C. Gerson. (*Nature, Lond.*, 19th Aug. 1950, Vol. 166, No. 4216, pp. 316–317.) Very marked and rapid sporadic-E movements during the period 15th–16th May 1949 are indicated according to preliminary information supplied by a network of North-American amateur observers operating on frequencies around 50 Mc/s. Results are charted on a sketch-map. The displacements of the reflection points may be due either to movements of the atmosphere or to electron drift.

551.510.535 : 535.36 3045

Diffusion in the Ionosphere.—M. H. Johnson & E. O. Hulburt. (*Phys. Rev.*, 1st Sept. 1950, Vol. 79, No. 5, pp. 802–807.) "Diffusion is treated by showing that the action of a medium on a diffusing gas is that of a dissipative force. When the theory is applied to an electrically neutral ionic gas in a gravitational field it is found that the mixture of positive and negative ions diffuses as a single gas because of the electrical polarization charges within the ionic cloud. In the presence of a magnetic field, the diffusion cannot be expressed in terms of the ionic density until the electrodynamical equations governing the flow of electrical current have been explicitly solved. Solutions are obtained for special cases which show that a strong magnetic field completely inhibits the diffusion due to concentration gradients in the transverse plane and has little effect on the diffusion due to the gravitational force."

551.510.535 : 551.594.5 3046

Narrowly Limited Ionization Clouds at 125-km Height during an Auroral Disturbance.—D. Stranz. (*Arch. elekt. Übertragung*, June 1950, Vol. 4, No. 6, pp. 213–216.) Analysis of Swedish records of 15th/16th September 1948 showing sporadic-E reflections lasting 2½ hours. Corresponding records of variations of the magnetic vector are also given.

551.55 : 551.510.535 : 621.396.9 3047

Meteoric Echo Study of Upper Atmosphere Winds.—Manning, Villard, Jr. & Peterson. (*See* 3052.)

551.594.6 3048

Noise Levels in the American Sub-Arctic.—N. C. Gerson. (*Proc. Inst. Radio Engrs*, Aug. 1950, Vol. 38, No. 8, pp. 905–916.) The level of atmospherics on a frequency of 150 kc/s was studied over a period of six months in Northern and Southern Canada. The average, quasi-peak, and maximum peak levels were determined. Diurnal variation is absent or small in winter, but shows a marked increase in summer, with a minimum after sunrise and a maximum after sunset. As summer approaches, the noise-level rise occurs earlier and earlier. Static intensity is higher in June than in January and at southern stations noise increased progressively up to June. A rise in noise level at some stations in February is attributed to precipitation static caused by blizzards. The noise level varied as a nonlinear function of colatitude. Recorded data are included.

LOCATION AND AIDS TO NAVIGATION

621.396.9 : 551.5 3049

The Temperatures at the Tops of Radar Echoes Associated with Various Cloud Systems.—R. F. Jones. (*Quart. J. R. met. Soc.*, July 1950, Vol. 76, No. 329, pp. 312–330.)

621.396.9 : 551.5 3050

Radar Echoes.—J. E. N. Hooper & A. A. Kippax; R. F. Jones. (*Quart. J. R. met. Soc.*, July 1950, Vol. 76, No. 329, pp. 330–336.) Discussion on papers abstracted respectively in 2221 of October and 3042 above.

621.396.9 : 551.5 3051

Radar Weather Echoes.—Jones. (*See* 3042.)

621.396.9 : 551.55 : 551.510.535 3052

Meteoric Echo Study of Upper Atmosphere Winds.—L. A. Manning, O. G. Villard, Jr. & A. M. Peterson. (*Proc. Inst. Radio Engrs*, Aug. 1950, Vol. 38, No. 8, pp. 877–883.) The Doppler frequency shift imparted to continuous waves reflected from a meteoric ionization column in the 80–100-km height region enables the wind drift of the trail to be found. Statistical analysis enables average wind velocities to be measured to within about 20% and direction to within about 20°, in a period of one or two hours. Typical wind velocities were found to be about 125 km/hr during the early morning hours in the summer of 1949; occasional evidence of nonuniform wind structure was found.

MATERIALS AND SUBSIDIARY TECHNIQUES

531.743 : 621.396.611.21 3053

A Double-Crystal X-Ray Goniometer for Accurate Orientation Determination.—W. L. Bond. (*Proc. Inst. Radio Engrs*, Aug. 1950, Vol. 38, No. 8, pp. 886–889.) The slit system of an X-ray goniometer is replaced by an AT quartz plate, thus turning it into a double-crystal instrument suitable for accurate measurements on AT quartz plates. Errors due to temperature change and to X-ray refraction are discussed. Measurement accuracy to within about 0.1′ of arc is attained.

533.5 3054

Measurement of the Pumping Rate of Rotary Pumps.—R. Henry. (*Le Vide*, July/Sept. 1950, Vol. 5, Nos. 28/29, pp. 859–865.) Fundamental definitions are stated, the method and apparatus used are described, and results obtained with various French and American models are tabulated.

535.215.1 : 549.211 3055

Photoelectric Properties of Diamond, Measured with a Crystal Counter.—G. P. Freeman & H. A. van der Velden. (*Physica, 's Grav.*, May 1950, Vol. 16, No. 5, pp. 486–492. In English.)

535.37 3056

Dependence of Emission Spectra of Phosphors upon Activator Concentration and Temperature.—G. R. Fonda. (*J. opt. Soc. Amer.*, June 1950, Vol. 40, No. 6, pp. 347–352.)

535.37 3057

The Rise in Brightness of Infrared-Sensitive Phosphors.—P. Brauer. (*J. opt. Soc. Amer.*, June 1950, Vol. 40, No. 6, pp. 353–355.)

535.37 : 546.472.54 **3058**

Rise and Decay of Willemite Luminescence.—G. Gergely. (*J. opt. Soc. Amer.*, June 1950, Vol. 40, No. 6, pp. 356–361.) The luminescence/time curve for c.r. excitation times of 1–280 μs can be resolved into three monomolecular components with time constants of 200, 1 800 and 72 000/sec. The fast component is predominant for short excitation times and the slow component for long times. The duration of excitation does not affect the decay rates, but varies the proportions of the three components.

537.363 + 621.357.1] : 546.841 **3059**

On the Polarization of the Electrodes in the Electrophoresis and the Electrolysis of Thoria and Thorium Nitrate.—G. Mesnard. (*La Vide*, July/Sept. 1950, Vol. 5, Nos. 28/29, pp. 866–869.)

538.27 : 621.314.22.042.2.029.6 **3060**

Theory of Magnetically Inhomogeneous Surface Layers in Transformer Laminations.—R. Feldtkeller. (*Frequenz*, June 1950, Vol. 4, No. 6, pp. 129–134.)

539.11 : 621.315.612.4 **3061**

Atomic Positions and Vibrations in the Ferroelectric $BaTiO_3$ Lattice.—W. Kaenzig. (*Phys. Rev.*, 1st Oct. 1950, Vol. 80, No. 1, pp. 94–95.)

539.2 : 537.228.1 **3062**

Domain Structure of Rochelle Salt.—J. Furuichi & T. Mitsui. (*Phys. Rev.*, 1st Oct. 1950, Vol. 80, No. 1, pp. 93–94.)

539.234 **3063**

Production of Thin Layers of Uniform Controlled Thickness by Evaporation: Applications in Electronics.—C. Dufour. (*La Vide*, July/Sept. 1950, Vol. 5, Nos. 28/29, pp. 837–843.) Illustrated description of methods used for producing thin layers such as are required especially in television and radar tubes. Layers uniform to within about 1% have been produced on a plane surface 20 cm in diameter, the thickness being controlled photoelectrically during processing to within about 0.02 μ.

546.431.82 **3064**

Ferroelectricity, Domain Structure, and Phase Transitions of Barium Titanate.—A. von Hippel. (*Rev. mod. Phys.*, July 1950, Vol. 22, No. 3, pp. 221–237.) Detailed summary of M.I.T. research to date, with discussion of: variations in the ferroelectric parameters of multicrystalline $BaTiO_3$ cooling through the Curie region; piezoelectric response with changing frequency and temperature; hysteresis phenomena; phase transitions of the BaO-TiO_2 system; the domain structure of $BaTiO_3$ single crystals and the effect of an applied electric field; theory of the ferroelectric state in $BaTiO_3$. Extensive references and many diagrams are included.

549.514.5 : 621.3.011.5 **3065**

Dielectric Constant of Silica.—S. K. K. Jatkar & B. R. Y. Iyengar. (*Indian J. Phys.*, April 1949, Vol. 23, No. 4, pp. 145–152.) The permittivities of crystal-quartz and fused-silica plates, as determined by the plate-capacitor method, are respectively 4.54 and 3.2. Measurements by the liquid-mixture method give for powdered quartz the value 4.55. The results are discussed with reference to the theory of molecular structure.

620.19 **3066**

Investigations into Tropic Proofing of Electrical Materials, 1943-46: Parts 1-5.—(*Aust. J. appl. Sci.*, March 1950, Vol. 1, No. 1, pp. 80–132.)

Part 1. The protection of electronic equipment for use under humid tropical conditions.—L. G. Dobbie. An outline of investigations in Australia. Moisture was found the main cause of electrical deterioration, particularly under unsuitable storage conditions. Suitable materials, protective coatings and lay-out are suggested and laboratory tests outlined. Complete hermetic sealing of components is the most satisfactory method of protection. Two appendices give general data on evaporation and water-vapour diffusion.

Part 2. The influence of moisture on insulating materials.—J. S. Dryden & P. T. Wilson. Limitations of methods commonly used for measuring surface and volume resistivity are discussed. Different types of material are compared; surface-treated glass and ceramics were found the best for maintaining high values of insulation resistance under humid conditions.

Part 3. Some experiments on the application of organosilicon compounds to glass and ceramic.—R. J. Meakins, J. W. Mulley & V. R. Churchward. The insulation resistance of glass and steatite at high relative humidities is increased by treatment with a solution of methyl or ethyl chlorosilane in benzene. Similar results are obtained with methyl- and ethyl-silicon-amine solutions, but prior cleaning with chromic acid is essential.

Part 4. The treatment of glass and steatite ceramic with quaternary ammonium compounds.—R. J. Meakins. Insulation resistance of glass and steatite is increased nearly 1 000 times after immersion for one second in an aqueous solution of certain quaternary ammonium compounds, but as a practical means of surface treatment these compounds are less effective than the alkylchlorosilanes.

Part 5. The corrosion of copper wires at d.c. potential in contact with electrical insulating materials.—R. J. Meakins. The anodic corrosion of copper wire in contact with a wide range of insulating materials under very moist conditions was investigated. Results indicate that the degree of corrosion depends on the affinity for water of the insulator. With polar materials, such as cellulose products, severe corrosion occurred, but little corrosion was found with nonpolar materials such as paraffin and ceresine waxes, bitumens and polyethylene.

621.3.011.5 : 676.19 **3067**

Investigations of the Dielectric Properties of Paper Fibre.—P. Henninger. (*Frequenz*, July 1950, Vol. 4, No. 7, pp. 167–177.) The experimentally determined dielectric properties of different types of paper are discussed in the light of its cellulose structure. Temperature coefficients for the different structures and the effect of absorption of water are studied.

621.3.032.2 : 621.315.61 : 68 **3068**

Microspacer Electrode Technique.—O. M. Stuetzer. (*Proc. Inst. Radio Engrs*, Aug. 1950, Vol. 38, No. 8, pp. 871–876.) Closely spaced multiple-electrode systems with glass, quartz or other thermoplastic insulation can be produced by drawing down from a convenient larger size, the geometry of the system undergoing little change in the process. Electrode materials can in some cases be inserted prior to the drawing in others, wires of suitable size are inserted after drawing and sealed if necessary. Applications of the technique in the construction of subminiature valves, crystal amplifiers, and flat parallel-wire screens, are described.

621.315.592† **3069**

On the Nature of a Soldered Contact on a Semiconductor.—J. I. Pantchechnikoff. (*Phys. Rev.*, 15th Sept. 1950, Vol. 79, No. 6, pp. 1027–1028.) An account of experiments made to verify the assumption that the soldered contact is effectively a gradual transition from a metal to a semiconductor. Metal atoms diffuse into the semiconductor during the soldering process, their concentration being greatest near the surface through which they have diffused. A theoretical explanation of effects observed with soldered contacts is given.

621.315.592† : [621.316.86 + 621.314.632 3070

Semiconductors and their Applications.—R. W. Douglas. (*G.E.C. J.*, July 1950, Vol. 17, No. 3, pp. 107–124.) Conduction in metals is considered and a typical crystal structure for a metal is contrasted with that of a semiconductor. Intrinsic, impurity and non-stoichiometric types of semiconductors are considered and their properties discussed from the chemical-bond viewpoint and more fully in terms of quantum mechanics. Applications discussed in detail include thermistors, point-contact rectifiers, high-back-voltage Ge diodes, layer-type rectifiers and Ge triodes.

621.315.61 3071

Fluid Dielectrics for the Decimetre and Centimetre Wave Band.—W. Endres & H. Köhler. (*Frequenz*, June 1950, Vol. 4, No. 6, p. 145.) Correction to paper abstracted in 1708 of July.

621.318.23 3072

The Design of [magnetic] **Circuits for Permanent Magnets.**—A. Hug. (*Bull. schweiz. elektrotech. Ver.*, 2nd Sept. 1950, Vol. 41, No. 18, pp. 661–669. In German.) A semi-empirical method of calculation is described which is simple yet sufficiently accurate for practical purposes. Electrical analogies are used in explaining the theory. Magnetizing processes and measurements on permanent magnets are discussed briefly.

621.318.4.042.15 : 538.22 3073

The Magnetic Characteristics of Coils with Pot-Type Cores of Powdered Iron.—M. Kornetzki. (*Frequenz*, May 1950, Vol. 4, No. 5, pp. 105–113.) Inductance and iron losses of such coils with a high-μ pot core completely enclosing the coil are calculated theoretically and referred to constants for the material measured on ring cores. The effective permeability of the pot core is proportional to that of the core material, but the proportionality factor depends on the type of winding. Losses due to eddy currents and magnetic after-effect are practically equal to those of the ring core. Hysteresis losses are determined from a calculation of effective length of magnetic path. Measurements on pot-type coils confirm the calculations. The effect of the stray field of these coils is discussed.

621.646.958 : 537.534 3074

Positive-Ion Emission, a Neglected Phenomenon.—W. C. White. (*Proc. Inst. Radio Engrs*, Aug. 1950, Vol. 38, No. 8, pp. 852–857.) General discussion, with description of a leak detector based on positive-ion effects.

666.1 : 621.317.374 3075

Some Experiments and Theories on the Power Factor of Glasses as a Function of Their Composition: Part 1.—J. M. Stevels. (*Philips Res. Rep.*, Feb. 1950, Vol. 5, No. 1, pp. 23–36.) Power factors and permittivities of various series of glasses of systematically graded composition were measured at a temperature of 20° C and a frequency of 1.5 Mc/s. Results are given in tables and graphs.

669.018.58 3076

Recent Developments in Magnetic Materials.—H. Fahlenbrach. (*Z. Ver. dtsch. Ing.*, 21st July 1950, Vol. 92, No. 21, pp. 565–570.) A survey with 38 references. The modifying effect of the new materials on the design of apparatus is indicated, both where permanent magnets and where electromagnets are used.

679.5 : [53 + 54 3077

Fundamentals of Synthetic-Polymer Technology in its Chemical and Physical Aspects. [Book Review]—R. Houwink. (Elsevier's Polymer Series, No. 1.) Publishers: Elsevier Publishing Co., New York and Amsterdam & Cleaver-Hume Press, London, 1948–1950, 258 pp., 28s. (*Nature, Lond.*, 7th Oct. 1950, Vol. 166, No. 4223, pp. 575–577.) "The subject matter includes the molecular and colloid chemistry of polymers, their more important mechanical and physical properties and methods of testing these, and their general processing, followed by an account of the manufacture and outstanding properties of industrial products of this type, whether obtained by chemical treatment of natural colloidal products or by synthesis from non-colloid raw materials."

679.5 : [53 + 54 3078

Elastomers and Plastomers: their Chemistry, Physics and Technology. [Book Review]—R. Houwink (Ed.). (Elsevier's Polymer Series, No. 3.) Publishers: Elsevier Publishing Co., New York and Amsterdam & Cleaver-Hume Press, London, 1948–1950. Vol. 1: General Theory, 495 pp., 52s. 6d. Vol. 2: Manufacture, Properties and Applications, 515 pp., 50s. 6d. Vol. 3: Testing and Analysis: Tabulation of Properties. Contributed by B. B. S. T. Boonstra, A. G. Epprecht, R. Houwink, J. H. Teeple, J. W. F. van't Wout. 174 pp., 27s. 6d. (*Nature, Lond.*, 7th Oct. 1950, Vol. 166, No. 4223, pp. 575–577.) The ground covered is similar to that for No. 1 (3077 above) but the treatment is much fuller and is extended to include also products such as natural resins and asphalts.

MATHEMATICS

519.21 + 519.271.3] : 517.9 3079

A Sampling Method for Determining the Lowest Eigenvalue and the Principal Eigenfunction of Schrödinger's Equation.—M. D. Donsker & M. Kac. (*Bur. Stand. J. Res.*, May 1950, Vol. 44, No. 5, pp. 551–557.)

519.3 3080

A Variational Method Suitable for studying the Wave Equation.—T. Kahan. (*Rev. sci., Paris*, Oct./Dec. 1949, Vol. 87, No. 3304, pp. 205–211.)

681.142 3081

Arithmetic Operations in a Binary Computer.—R. F. Shaw. (*Rev. sci. Instrum.*, Aug. 1950, Vol. 21, No. 8, pp. 687–693.)

681.142 3082

Electronic Pile Simulator.—P. R. Bell & H. A. Straus. (*Rev. sci. Instrum.*, Aug. 1950, Vol. 21, No. 8, pp. 760–763.) A calculator is described which can deal with the set of equations applicable to a chain-reaction pile. The voltage output varies as a function of time just as the neutron flux would vary in a pile. A potentiometer varies the effective multiplication factor and simulates the action of a control rod. Five delayed neutron periods are simulated. An electronic integrator is used and the accuracy is well within 1%.

681.142 3083

Programme Organization and Initial Orders for the EDSAC.—D. J. Wheeler. (*Proc. roy. Soc. A*, 22nd Aug. 1950, Vol. 202, No. 1071, pp. 573–589.)

681.142 3084

Solution of Simultaneous Equations through Use of the A.C. Network Calculator.—L. M. Haupt. (*Rev. sci. Instrum.*, Aug. 1950, Vol. 21, No. 8, pp. 683–686.)

51 3085

Progressive Mathematics. [Book Review]—P. Clyne. Publishers: Chapman & Hall, London, 1950, 270 pp., 15s. (*Beama J.*, Aug. 1950, Vol. 57, No. 158, p. 239.) Directed mainly to students of engineering and physics up to the Higher National Certificate standard. Some unorthodox methods are used. "The book is well printed and produced, and its modest price should be the means of making it available to most students."

MEASUREMENTS AND TEST GEAR

621.37.1 : 621.397.61 : 621.396.619.24 **3086**

Television Transmitter Lower-Sideband Measurements.—G. E. Hamilton & R. G. Artman. (*TV Engng, N.Y.*, April & May 1950, Vol. 1, Nos. 4 & 5, pp. 12–15, 25 & 14–15, 30.) Theoretical and practical consderations are discussed which are involved in the measurement of the spectral energy distribution of television signals. Account is taken of transmitter adjustment and receiver sensitivity. Measurement methods described include (*a*) r.f. excitation of the input circuit of the modulation amplifier, (*b*) sine-wave modulation of the transmitter, (*c*) composite-video-signal modulation of the transmitter. Method (*b*) is preferred.

621.317.3/.4 : 621.315.592 **3087**

Measurement of Electric and Magnetic Constants of Semiconductors at Ultra-High Frequency using Concentric Line.—G. Untermann. (*Z. angew. Phys.*, June 1950, Vol. 2, No. 6, pp. 233–241.) The formulae necessary for evaluating measurements on concentric lines are derived. Calculations are facilitated by the graphical presentation of certain functions, notably $x \cot x$ and $x \tan x$ for complex arguments. By means of these it is possible to determine rapidly the values of dielectric constant, conductivity, permeability and magnetic loss angle at u.h.f.

621.317.3.029.6 **3088**

Lines and Circuit Elements for Microwave Measurements.—O. Schäfer & R. Honerjäger. (*Arch. tech. Messen*, Aug. 1950, No. 175, pp. T87–T90.) Discusses propagation of e.m. waves in coaxial lines and waveguides, the design of terminations, attenuators, directional couplers, impedance bridges, resonator wavemeters, etc.

621.317.321.027.21 **3089**

The Low-Loss Measurement of Direct Voltage by Conversion into Alternating Voltage.—H. H. Rust. (*Z. angew. Phys.*, July 1950, Vol. 2, No. 7, pp. 290–293.) The method previously described (1451 of June) using a carbon microphone as transducer is only suitable if the resistance of the d.c. source is low; otherwise a capacitor microphone is more appropriate, on account of its high input resistance. The unknown direct voltage is used as a polarizing voltage, and a proportional a.c. output is obtained when the microphone is exposed to a tone of constant amplitude and frequency (here 2 kc/s). With an aperiodic amplifier the lowest voltage measurable is 10^{-2} V, but sensitivity can be increased by using a selective amplifier.

621.317.324(083.74)† **3090**

Development of Very-High-Frequency Field-Intensity Standards.—F. M. Greene & M. Solow. (*Bur. Stand. J. Res.*, May 1950, Vol. 44, No. 5, pp. 527–547.) A description is given of the development of two field-intensity stapdards which are being used at the National Bureau of Standards for the calibration of commercial field-intensity sets in the range 30–300 Mc/s. These standards are employed to establish known values of field intensity by either of two methods: (*a*) the standard-aerial method in which the open-circuit voltage at the centre of a receiving dipole is measured directly; (*b*) the standard-field method in which the current at the centre of a transmitting dipole is accurately known. The techniques used for determining the aerial current and voltage are described. The current distribution on the aerial is determined theoretically, using Schelkunoff's method, which gives the effective length. These values are compared with those obtained by measurement. Results of field tests at 100 Mc/s are presented in which the above two methods were directly compared, using horizontal polarization. Their accuracy and limitations are discussed.

621.317.333.4.015.7 : 621.315.2 **3091**

Location of Line Faults by Oscillographic Observation of a Pulse.—C. Béguin & G. Maugard. (*Bull. Soc. franç. Élect.*, July 1950, Vol. 10, No. 106, pp. 313–328.) A theoretical study is made of the conditions of propagation of a pulse along a line and of the distortion of pulses reflected at line faults. The pulse method of investigation is particularly suitable for coaxial telephone lines and h.v. cables, but not for lines with high attenuation. Equipment described uses a circular timebase, with arrangements for locating the steep front of the initial pulse at the zero of the scale. Pulse duration is 1–4 μs, depending on the circuit range, and peak power is 250 W. Tests on power lines are described in detail; the method is quicker than the bridge method.

621.317.335.3.029.62/.63† **3092**

Complex-Dielectric-Constant Measurements in the 100-1 000-Mc/s Range.—A. G. Holtum, Jr. (*Proc. Inst. Radio Engrs*, Aug. 1950, Vol. 38, No. 8, pp. 883–885.) A sample of a medium-loss or high-loss material is used as the dielectric of a capacitor terminating a slotted measuring line. The complex impedance of this termination, and hence the dielectric constant and conductivity of the lossy material, can be determined by the conventional method from the voltage s.w.r. and the position of the minimum.

621.317.336.029.64 **3093**

The Accuracy of Impedance Measurement with Microwaves.—F. Tischer. (*Kungl. tekn. Högsk. Handl., Stockholm*, 1950, No. 36, 31 pp. In German, with English summary.) The theory of impedance matching is discussed and standing-wave ratio and matching error are defined; approximate formulae are derived for the case of small errors. Known types of apparatus, such as reflectometers, directional couplers, impedance bridges and comparators, are discussed. The method using a standing-wave meter is dealt with at length, this giving the best accuracy. Errors originate from two sources, the line discontinuities of the standing-wave meter and the probe used as voltage pickup. The errors can be largely eliminated by proper design. The results of the investigation have been applied in the development of two instruments, one a precision meter giving the s.w.r. to within 0.5% and the other a rotary automatically recording meter for the 10-cm band, accurate to within 3%.

621.317.352 : 621.392.5 **3094**

Determination of Attenuation from Impedance Measurements.—R. W. Beatty. (*Proc. Inst. Radio Engrs*, Aug. 1950, Vol. 38, No. 8, pp. 895–897.) The dissipative and reflective components A_d and A_r of a linear, passive, quadripole attenuator are measured separately. A_d, a function of the attenuator efficiency, is determined from reflection-coefficient measurements of the short-circuited attenuator and A_r from a single voltage-s.w.r. measurement with the attenuator terminated by a matched load. Experimental results are in close agreement with measurements by another method.

621.317.432 **3095**

Eddy-Current Losses in Electrical Equipment.—A. Roth. (*Rev. gén. Élect.*, June 1950, Vol. 59, No. 6, pp. 268–278.) Formulae are derived and graphs presented for rapidly finding the approximate value of eddy-current losses in various cases. Numerical examples are given. Wattmeter methods used in industry for measuring these losses are reviewed, and precautions necessary when using them are indicated. A simple voltmeter method is described.

621.317.7 : 621.314.632.1† **3096**

Design of Square-Law Rectifier Circuits for Measuring Instruments.—D. C. Walker, D. L. Richards & G. F. Horton. (*P.O. elect. Engrs' J.*, July 1950, Vol. 43, Part

2, pp. 74–77.) For accurate r.m.s. indications of speech currents, a scale having a range of at least 16 db is desirable. Networks consisting of rectifiers in combination with series and shunt resistors are described with which measurement accuracies to within about ±0.3 db have been achieved.

621.317.723 **3097**

New Types of Electrometer.—P. Böning. (*Arch. tech. Messen*, June 1950, No. 173, p. T70.) The device described consists basically of a metal cylinder, with axis horizontal, containing a fixed metal frame electrically connected to a similar frame rotatable about the axis and carrying a pointer. A potential to be measured is applied between cylinder and frames. The theory of operation is given.

621.317.726 **3098**

The New Modulation Meter.—M. Bidlingmaier. (*Frequenz*, June 1950, Vol. 4, No. 6, pp. 146–149.) Description of a peak voltmeter with an approximately logarithmic scale and an optical indicator system. The scale covers an amplitude range of about 1 : 300 and peaks of duration as short as 10 ms can be measured within 1 db.

621.317.755 **3099**

Oscillograms obtained without Timebase: 'Integral Curve' Method.—F. Perrier. (*Rev. gén. Elect.*, Aug. 1950, Vol. 59, No. 8, pp. 345–351.) A c.r.o. method is described in which a function is compared with its derivative. Examples of application include both slowly varying and rapid phenomena. Oscillograms reproduced correspond to the superposition of more than 10^3 curves and demonstrate the immobility of the trace on the screen. Thus long photographic exposures can be used to give the mean value, and the fluctuations about the mean value, of phenomena repeating at irregular intervals.

621.317.755 : 621.3.012 **3100**

High-Frequency Curve Tracer for 460-480 kc/s and 10.0-11.5 Mc/s.—A. Klemt. (*Funk u. Ton*, Aug. 1950, Vol. 4, No. 8, pp. 396–402.) A c.r.o. is described for checking i.f. band-pass filters and aligning i.f. amplifiers of broadcast receivers. The upper frequency range deals with f.m. receivers, where particular care is required.

621.317.772 **3101**

High-Frequency Phase Measurement with Direct Indication: Part 2—With Pointer Indicators.—A. Ruhrmann. (*Arch. tech. Messen*, June 1950, No. 173, pp. T64–65.) The pointer instrument has the advantage over the c.r.o. as regards simplicity of operation and long life. Arrangements using crossed-coil and four-quadrant indicator instruments are discussed. Part 1: 2574 of October.

621.317.79 : 621.396.822 : 621.396.61 **3102**

An Instrument for the Determination of Frequency-Modulated Hum in a Radio-Frequency Signal.—W. W. Boelens. (*Commun. News*, April 1950, Vol. 10, No. 4, pp. 101–109.) The instrument uses a very sensitive ph.m. detector which can be calibrated without any additional apparatus. The theory of the method of hum measurement [2837 of 1949 (Boelens & Stumpers)] is outlined and several special circuits incorporated in the apparatus are described. These include a high-pass filter without any inductance, a double-T RC filter and an attenuator.

621.385.001.4(083.74) **3103**

Standards on Electron Tubes: Methods of Testing, 1950.—(*Proc. Inst. Radio Engrs*, Aug. & Sept. 1950, Vol. 38, Nos. 8 & 9, pp. 917–948 & 1079–1093.) Reprints of this standard, 50IRE7.S2 (Parts I & II) may be purchased while available from The Institute of Radio Engineers, 1 East 79th Street, New York 21, at $1.25 per copy, with 20% discount for 100 or more copies.

621.396.621.001.4 **3104**

Critical Study of Measurements on Receivers.—L. Chrétien. (*T.S.F. pour Tous*, June 1950, Vol. 26, No. 260, pp. 212–217.) Methods of making electrical measurements to determine receiver performance are discussed. Standards are fixed for a.m. test signal, dummy aerial for medium and short waves, output signal, sensitivity necessary to give this output in the presence of noise. The best simple methods of checking the efficiency of the automatic control circuits and measuring the selectivity and distortion are indicated. One criticism of normal tests is that a receiver which is judged 'perfect' according to such tests may not entirely satisfy the ear of a true artist.

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

536.53 : 621.316.8 : 621.396.822 **3105**

The Use of Spontaneous Voltage Fluctuations for the Measurement of Low Temperatures.—P. M. Endt. (*Physica, 's Grav.*, May 1950, Vol. 16, No. 5, pp. 481–485. In English.) Discussion of Lawson & Long's method (483 of 1947). The statistical fluctuations in the measured noise are calculated, taking account of the bandwidth of the amplifier. The calculation shows that it is not necessary to use reduced anode, screen-grid, and heater voltages on the input valve, and that a quartz crystal is essentially worse than a resistor or an LC circuit as a noise generator for temperature measurement.

536.58 : 621.314.3† **3106**

A Direct-Voltage Amplifier as Power Amplifier and Temperature Regulator.—Jellinghaus. (*See* 2990.)

537.533.73 : 621.315.611 : 539.213.26 **3107**

Electron Diffraction Apparatus for investigating Insulator Surfaces.—J. J. Trillat & S. Oketani. (*Le Vide*, July/Sept. 1950, Vol. 5, Nos. 28/29, pp. 827–830.) The apparatus, which is described in detail, includes a new type of neutralizing gun for preventing accumulation on the specimen of negative charges carried by the exploring beam. This gun uses a platinum filament coated with barium and strontium oxides and operated at a temperature below that at which vaporization occurs. Thus the investigation can extend over a long period without the specimen becoming coated. Photographs are shown of diagrams obtained with the apparatus.

538.569.2.047 : 621.315.61.011.5 **3108**

Dielectric Properties of the Human Body for Wavelengths in the 1–10-cm Range.—T. S. England. (*Nature, Lond.*, 16th Sept. 1950, Vol. 166, No. 4220, pp. 480–481.) Previously reported measurements on a wavelength of 3.18 cm (2282 of 1949) have been repeated on wavelengths of 1.27 cm and 10.0 cm. Results are tabulated and discussed, using the values obtained for water as a comparison standard.

539.16 : 614.8 **3109**

Measurement Apparatus for the Protection of Personnel against Radioactive Radiations.—J. Weill. (*Onde élect.*, July 1950, Vol. 30, No. 280, pp. 328–334.) The various radiations to be guarded against and the measurement of their intensity by means of photographic plates, Geiger counters and ionization chambers are briefly described.

549.514.51.001.8 **3110**

Applications of Quartz Crystals.—R. Villem. (*Rev. gén. Elect.*, June 1950, Vol. 59, No. 6, pp. 247–268.) The equivalent circuit of the quartz crystal and the order of magnitude of the impedances involved are discussed. The mechanisms of oscillation stabilization and of frequency selection are studied, and the advantages of using crystals for these purposes are demonstrated.

Applications described in detail include a highly stable generator for common-frequency broadcasting, the Lepaute oscillometer for observing the operation of watches, underwater sounding equipment, ultrasonic generators, and devices for measuring pressure, especially in machine tools, vehicles and power-line pylons. Filters making use of quartz crystals receive special attention. An appendix gives a résumé of the properties of T, Π ladder and bridge filters.

621.317.755 **3111**

A Cathode-Ray Oscillograph for investigating Functions of Two Variables.—S. Genç. (*Tech. Mitt. schweiz. Telegr.-TelephVerw.*, Sept. 1950, Vol. 28, No. 9, pp. 342–348. In German.) A description is given of a c.r.o. with which the functions are displayed as surfaces in three dimensions. Circuit relations are established by means of which the usual deflector system comprising two mutually perpendicular e.m. fields is able to produce spot displacements corresponding to a three-field deflector system. Several photographs of screen displays are shown.

621.365.54† **3112**

A General Theory and Methods of Design for Medium-Frequency [electric] **Furnaces.**—M. Van Lancker. (*Bull. Soc. franç. Élect.*, Sept. 1950, Vol. 10, No. 108, pp. 439–455. Discussion, pp. 455–456.) Simple and generalized penetration are discussed. Parameters affecting the resistance and inductance for a furnace of infinite length are calculated, and coefficients of resistance and generalized inductance and correction factors for furnaces of finite length are derived. Form factor, field factors, and total input power are investigated. The theory is applied to the study of the design of an industrial furnace.

621.365.54† **3113**

Rapid Tempering by Induction Heating.—J. F. Libsch & A. E. Powers. (*Metal Progress*, Aug. 1950, Vol. 58, No. 2, pp. 176–180.) Short-term tempering may be performed successfully on carbon and low-alloy steels by the induction-heating method, provided the temperature is increased to compensate for the reduced time.

621.383 : 621.385.15 : 535.245.1 **3114**

Detection of Short Pulses of Light using an Electron-Multiplier Circuit.—F. Valentin. (*C. R. Acad. Sci., Paris*, 26th June 1950, Vol. 230, No. 26, pp. 2271–2272.) Light pulses from a Hg arc, with a repetition rate of 50 per sec and an instantaneous brilliance inversely proportional to their duration, are used in experiments on the molecular diffusion of light, the re-emitted flashes being received by a multiplier connected to a suitable amplifier. The signal is modulated at h.f. to enable a mains-operated a.c. amplifier to be used. Signal/noise ratio of the circuit is compared with that of a classic d.c. amplifier; for flashes of duration 80 μs the two are about equal, but in the new circuit the threshold of detection can be considerably reduced by shortening the flashes.

621.384.611.1† **3115**

The Theory of Electron Acceleration in the Alternating Magnetic Field.—Picht. (*See* 3034.)

621.384.611.2† : 621.316.726 **3116**

Frequency Control for the Bevatron Radio-Frequency Voltage.—J. Riedel. (*Elect. Engng, N.Y.*, Aug. 1950, Vol. 69, No. 8, pp. 721–722.) Summary of A.I.E.E. Summer General Meeting paper. The variable element in the control oscillator is a saturable inductance consisting of toroidal coils wound on ferroxcube III.

621.385.833 **3117**

Contrast Improvement in Electron Microscopy.—J. Hillier & E. G. Ramberg. (*Z. angew. Phys.*, July 1950, Vol. 2, No. 7, pp. 273–278.) Methods of preparing specimens so as to obtain optimum contrast are discussed.

621.385.833 **3118**

Electron-Optical Properties of Space-Charge Clouds.—L. Marton & D. L. Reverdin. (*J. appl. Phys.*, Aug. 1950, Vol. 21, No. 8, p. 842.) Tests have been made which tend to confirm the suggestion that a space-charge lens might be used as a corrective element for the reduction of the aperture defect of electron lenses. However, the experiments also support the idea that the random noise in such a space-charge cloud might reduce image definition.

621.385.833 **3119**

New Simplified Electron Microscopes.—V. E. Cosslett. (*Nature, Lond.*, 19th Aug. 1950, Vol. 166, No. 4216, pp. 305–306.) A British and an American model are briefly described, both operating at 50 kV and giving a resolving power approaching 100 Å; they cost much less than standard models hitherto available.

621.387.4† **3120**

A New Method of Operating Counter Tubes with High Resolving Power.—A. Trost. (*Z. angew. Phys.*, July 1950, Vol. 2, No. 7, pp. 286–289.) A method using a thyratron circuit provides direct quantitative indication of intensity even at the very high pulse rates encountered with powerful X-rays or γ-rays. An experimental investigation of the life of quenched counter tubes is also described.

621.387.4† **3121**

The Behaviour of Counters with Pure-Vapour Filling in the Proportional and Geiger Regions.—E. Fünfer & H. Neuert. (*Z. angew. Phys.*, June 1950, Vol. 2, No. 6, pp. 241–249.) The variation of pulse height with tube voltage was measured for various vapours, and for α- and β- radiation. Counters with pure-vapour filling have a much more extensive proportional region than mixture-filled counters. For β-radiation the limit of the true proportional region corresponds to amplification factors of 10^6–10^7. With heavy vapours so-called 'oversize' pulses may occur.

621.387.4† **3122**

Three Examples of Electronic Apparatus used for [particle] **Detection.**—G. Valladas. (*Onde élect.*, July 1950, Vol. 30, No. 280, pp. 317–320.) The auxiliary apparatus required with particle detectors, viz. amplifier, selector and recorder, is discussed.

621.387.4† : 549.211 **3123**

Mobility of Electrons and Holes in Diamond.—E. A. Pearlstein & R. B. Sutton. (*Phys. Rev.*, 1st Sept. 1950, Vol. 79, No. 5, p. 907.) From c.r.o. measurements of pulse rise times with voltages of 300–5 000 V applied across a crystal of thickness 2 mm, the mobilities deduced for electrons and holes were respectively 3 900 and 4 800 cm^2/sec.V, with possible errors of 15% and 20%.

621.387.4† : 549.211 : 535.215 **3124**

The Influence of Red and Infra-red Light on a Crystal Counter.—H. A. van der Velden & G. P. Freeman. (*Physica, 's Grav.*, May 1950, Vol. 16, No. 5, pp. 493–500. In English.) The influence of red light in reducing the space charge built up in a diamond crystal counter is investigated. The counting property of the crystal can be maintained for an unlimited time if the intensity of the incident light is sufficient.

621.387.42† **3125**

High-Pressure Ionization-Chamber Counters and their Use.—R. Wilson, L. Beghian, C. H. Collie, H. Halban & G. R. Bishop. (*Rev. sci. Instrum.*, Aug. 1950, Vol. 21, No. 8, pp. 699–705.) New techniques and counters filled with H_2, D_2 or CH_4 at pressures up to 35 atm., and also the characteristics and applications of these counters, are described.

621.387.42 : 621.3.015.7 **3126**

Pulses in Argon Counters.—L. Colli, U. Facchini & E. Gatti. (*Phys. Rev.*, 1st Oct. 1950, Vol. 80, No. 1, pp. 92–93.)

621.387.422 **3127**

Boron Trifluoride Proportional Counters.—I. L. Fowler & P. R. Tunnicliffe. (*Rev. sci. Instrum.*, Aug. 1950, Vol. 21, No. 8, pp. 734–740.) Counters with filling of BF_3 and of calculable efficiency for neutron-beam measurements are described.

621.398 **3128**

Remote Control of [atomic] Pile Reaction.—J. Pottier & V. Raievski. (*Onde élect.*, July 1950, Vol. 30, No. 280, pp. 323–327.) A servo arrangement is described which has been in operation without interruption for a year and which controls the position of a neutron-absorbing plate within a cavity in the pile.

621.385.833 **3129**

Electron Microscopy: Technique and Applications. [Book Review.]—R. W. G. Wyckoff. Publishers: Interscience, New York and London, 1949, 248 pp., 40s. (*Nature, Lond.*, 19th Aug. 1950, Vol. 166, No. 4216, pp. 285–286.) Includes much to instruct and interest specialists, but appeals also to a far wider audience by providing in effect "the story of the new field of vision".

PROPAGATION OF WAVES

531.74 : 621.396.11.029.62 **3130**

Measurement of Small Angles of Elevation of Incoming Metre Waves. Part 1: Theory.—H. Stenzel. (*Arch. elekt. Übertragung*, April 1950, Vol. 4, No. 4, pp. 125–132.) Analysis shows that with aerial systems in the horizontal plane, with horizontal polarization and adjustable directivity in the vertical plane, the measurement of small angles of elevation for metre waves is only possible with aerials of impracticable dimensions. For vertical aerial systems with horizontal polarization, however, small angles of elevation can be measured if they are at least 3/4 of the half-value width of the directional characteristic, but in order to measure an angle of 4°, the size of the aerial system must be about 10 λ.

A new method is indicated which is based on the comparison of two fixed vertical systems with different directional characteristics, the midpoints being at equal heights above the ground. This method is particularly suitable for the measurement of angles down to ½ deg., since the dimensional requirements can be carried out in practice and the effect of the plane and horizontal ground is completely eliminated. This method will be considered more fully in part 2.

538.566 **3131**

Propagation of Electromagnetic Waves through a Stratified Medium: Part 1.—B. Salzberg. (*J. opt. Soc. Amer.*, July 1950, Vol. 40, No. 7, pp. 465–470.) A general analysis is developed which is applicable to propagation through a medium divided into m plane parallel layers, the first and last being semi-infinite. The e.m. properties of the layers are unrestricted and dissimilar, while the thicknesses of the $(m-2)$ finite layers are in general different. Formulae for the resulting reflection and transmission coefficients are derived. In part 2 the analysis will be applied to the detailed solution of specific problems.

621.396.11 + 621.396.67 **3132**

Symposium on Antennas and Propagation, San Diego, California, April 3-4, 1950.—(*Proc. Inst. Radio Engrs*, Aug. 1950, Vol. 38, No. 8, pp. 958–962.) Summaries are given of 38 papers presented at the conference.

621.396.11 **3133**

Elements of Anomalous Radio Propagation.—E. Knighting. (*Met. Mag.*, March 1950, Vol. 79, No. 933, pp. 74–81.) Discussion of the dependence of the refractive index of the atmosphere on the pressure, temperature and amount of water vapour. The changes with altitude of these parameters can explain radio reception at distances beyond the normal optical range, by refractive bending of the ray paths and by the formation of radio ducts.

621.396.11 **3134**

Passage of Electromagnetic Waves [of frequency] below the Critical Frequency, through Plasma Layers of Finite Thickness.—W. O. Schumann. (*Arch. elekt. Übertragung*, May 1950, Vol. 4, No. 5, pp. 173–174.) It is usually assumed that for frequencies below a certain critical frequency an e.m. wave incident perpendicularly on a plasma layer of infinite extent will be totally reflected, an exponentially damped stationary wave being produced within the plasma. In the case of a plasma layer of finite thickness it is found that energy can be transported through the layer, and appropriate formulae are derived.

621.396.11 **3135**

Reflection of Electromagnetic Waves at a Discontinuity of the Permittivity Gradient.—G. Eckart. (*Funk u. Ton*, July 1950, Vol. 4, No. 7, pp. 354–357.) A particular case, such as might occur in the troposphere, is considered and an expression is derived for the reflection coefficient (r). Unlike the Fresnel coefficient, r in this case is dependent on frequency, being smaller the shorter the wavelength. A table shows the angle of incidence, for values of λ from 1 cm to 1 000 m, at which $r = 1/100$, for two values of gradient jump. See also 977 of April.

621.396.11 : 535.42 **3136**

On the Diffraction of a Radar Wave by a Conducting Wedge.—R. B. Watson & C. W. Horton. (*J. appl. Phys.*, Aug. 1950, Vol. 21, No. 8, pp. 802–804.) "Diffraction patterns of radar waves have been measured about the edge of a perfectly conducting wedge. Theoretical patterns have been calculated using an asymptotic solution suggested by Pauli (906 of 1939). Good agreement is observed between experimental and calculated patterns. The thin wedge tested showed much similarity in diffracting properties to a suitable semi-infinite conducting screen."

621.396.11.029.51 **3137**

Polarization of Low-Frequency Radio Waves Reflected from the Ionosphere.—A. H. Benner, C. H. Grace & J. M. Kelso. (*Proc. Inst. Radio Engrs*, Aug. 1950, Vol. 38, No. 8, pp. 951–952.) Vertical-incidence measurements of the limiting polarization of 150 kc/s e.m. waves, together with theoretical calculations, indicate that (*a*) observed split echoes are not due to magneto-ionic splitting; (*b*) the polarization is left-handed; (*c*) the wave leaves the layer at a level where the collision frequency is roughly 0.8×10^6/sec.

621.396.11.029.55 **3138**

Investigations on the Propagation of Short Waves over Great Distances.—W. Messerschmidt. (*Arch. elekt. Übertragung*, May 1950, Vol. 4, No. 5, pp. 181–188.) Report of experiments conducted in 1938 on the possibility of zigzag reflections in the transmission of s.w. signals over great distances. The transit time of a pulse transmitted and re-transmitted over known distances was measured. Two fixed stations or one fixed station and one airborne re-transmitting station were used;

distances involved were chiefly about 8 000 km. The 'detour factor' (ratio of actual path length to great-circle distance) is correlated with the apparent height of the relevant ionospheric layer simultaneously measured at different places along the wave path. The transit time was often constant for long periods. At other times a jump from one value to another occurred; this is attributed to a variation in the number of zig-zag reflections.

621.396.11.029.55 **3139**

Studies of Multiple Circuits of the Earth by Short-Wave Signals.—H. A. Hess. (*Fernmeldetech. Z.*, July 1950, Vol. 3, No. 7, pp. 243–248.) Account of an investigation made on 19th November 1944, on a frequency of 19.947 Mc/s. Morse signals of duration 12 ms were sent out at 0.5-sec intervals from DLO (Berlin) and the echoes were observed at Randers (Denmark) and Gatow (Berlin). Results are shown graphically. The times for the second circuit lay between 0.137 6 and 0.138 4 sec. Periodic amplitude fluctuations of the echo were correlated with multiple paths and the movements of ionosphere layers. The high intensity maintained after repeated circuits is evidence of propagation in a narrow great-circle beam.

621.396.11.029.6 **3140**

The Propagation of Very Short Electromagnetic Waves.—A. Grün. (*Z. angew. Phys.*, July 1950, Vol. 2, No. 7, pp. 294–301.) Approximate formulae derived by geometrical ray treatment are compared with more accurate formulae taking account of diffraction. In the decimetre range certain simple approximations are sufficient, since reflection and divergence factors do not differ greatly from unity, and it is safe to neglect both irregularities of the earth's surface and the fine variation of refractive index with height. Fluctuations of ray curvature due to weather conditions are important in this frequency range, producing a variable interference field which is the main cause of fading; this can be overcome by suitable choice of wavelength, aerial height, and range. The effects of disturbing reflections from isolated obstacles and of unusual refraction phenomena are discussed briefly.

621.396.11.029.64 : 535.42 **3141**

Diffraction Pattern in a Circular Aperture Measured in the Microwave Region.—C. L. Andrews. (*J. appl. Phys.*, Aug. 1950, Vol. 21, No. 8, pp. 761–767.) Measurements were made of the diffraction patterns of circular apertures (of diameter from λ to 8λ) in and near the aperture planes, for incidence of a plane-polarized e.m. wave of 8-cm wavelength. From Young's theory the points of maximum intensity near the aperture were calculated and the results checked by experiment.

621.396.81 : 551.510.535 **3142**

Geometrical Optics of Ionospheric Propagation.—K. Rawer. (*Nature, Lond.*, 19th Aug. 1950, Vol. 166, No. 4216, p. 316.) Three focusing effects have been observed, due respectively to refraction, curvature of the reflecting layer, and the spherical form of the earth. Neither the first nor the third of these effects can be applied regularly for ionospheric prediction. The method of constructing a prediction curve (field-intensity/distance) to take account of the second effect is indicated. See also 514 of 1948, 717 of March and 1229 of May (Lejay & Lepechinski).

621.396.812.3 **3143**

Periodic Fading in Short-Wave Propagation.—H. A. Hess. (*Funk u. Ton*, July 1950, Vol. 4, No. 7, pp. 329–340.) Photographic records of wave-trains of signals received from long-distance oversea transmissions in 1944 are reproduced and analysed. Multiple-hop and round-the-world signals are considered in comparing ionospheric path lengths to determine the rapidity of movement of the reflecting layer. The beat frequencies observed in certain received signals, in one instance a 34-c/s frequency modulation of a 15-Mc/s signal, cannot be explained by vertical movement of the F-layer. In the region of the critical frequency, multiple reflections will not normally occur and fading is minimized. Similarly, periodic fading can be avoided by using strongly modulated telegraphy signals.

621.396.812.5 **3144**

Drift Phenomena for Rapid Fluctuations of Field Strength of Ionospheric Echoes.—J. Krautkrämer. (*Arch. elekt. Übertragung*, April 1950, Vol. 4, No. 4, pp. 133–138.) Observations obtained from three recorders in line indicate that drift of the reflection region may occur in the ionosphere. The magnitude and direction of the movement are determined from the difference in the time of observation of rapid fluctuations at three recording stations at the corners of a right-angled triangle. Velocities up to several hundred m/s have been observed. In the E layer a definite directional trend is noted, but in the F layer, where higher velocities are more frequent, no such trend is apparent. The observations are explained by an interference effect of the waves reflected from different irregularities in the layer. Preferred direction in the E layer is westward.

621.396.812.5 **3145**

Origin of the Mögel-Dellinger Effect.—H. Siedentopf. (*Arch. elekt. Übertragung*, March 1950, Vol. 4, No. 3, pp. 97–98.) Review of observations reported by various authors, and of possible causes of the effect.

621.396.812.5 : 523.746 **3146**

Results of Statistical Analysis of Fade-Outs.—D. Stranz. (*Arch. elekt. Übertragung*, June 1950, Vol. 4, No. 6, pp. 217–218.) Correlation of sunspot data with 130 cases of total disappearance of radio signals observed during 1948.

RECEPTION

621.396.621 **3147**

The Broadcasting Receiver and the Pickup Connection.—M. Lechenne. (*T.S.F. pour Tous*, June 1950, Vol. 26, No. 260, pp. 235–237.) Suggested additions to the receiver circuit to improve the quality of reproduction are: (*a*) at least 6 db non-selective negative feedback; (*b*) a special adjustable tone-control circuit with a linear potentiometer for the pickup position; (*c*) a 4.5- or 9-kc/s filter in the I.f. amplifier anode circuit.

621.396.621 : 621.396.822 **3148**

Receiver Sensitivity and its Limitation by Background Noise.—J. Rousseau. (*T.S.F. pour Tous*, June 1950, Vol. 26, No. 260, pp. 218–221.)

621.396.621.54 : 621.396.662.4 **3149**

Calculation of the Three-Point-Alignment Circuit in Superheterodyne Receivers.—O. Meisinger. (*Arch. elekt. Übertragung*, March 1950, Vol. 4, No. 3, pp. 99–104.) The whole of the auxiliary circuit, comprising fixed capacitors, which in superheterodyne receivers makes three-point alignment possible, is treated as a quadripole. Calculation shows that the short-circuit and open-circuit impedances, seen from the variable capacitor, are given by polynomials involving three parameters. Practical formulae and tables, of general application, are given which enable all the necessary calculations to be carried out with sufficient accuracy on a slide rule for inductance and capacitance values, bandwidth, etc.

621.396.621.57 3150

Receivers with Crystal Detectors ('Crystal-Video').—S. Marmor. (*Ann. Télécommun.*, July 1950, Vol. 5, No. 7, pp. 269–275.) Results are presented of measurements made at the C.N.E.T. on a silicon crystal of average characteristics at a wavelength of 10 cm. An explanation is given of the poor sensitivity of receivers using crystal detectors as compared with superheterodyne receivers. Difficulties encountered in constructing high-gain crystal-detector sets for pulse reception are described, and steps proposed by American designers (see 206 and 1638 of 1949) to prevent overshoots causing prolonged desensitization are reviewed. Details are given of a set designed at the C.N.E.T., and photographs are shown of the output pulses obtained.

621.396.8.015.7† : 621.396.822 3151

The Effect of a Video Filter on the Detection of Pulsed Signals in Noise.—D. Middleton. (*J. appl. Phys.*, Aug. 1950, Vol. 21, No. 8, pp. 734–740.) Theoretical examination of the effect of inserting a video filter of finite bandwidth on the observability of pulsed signals (of Gaussian or rectangular shape) in random noise. When the pulse and i.f. filter are matched, i.e., when they are each other's conjugate Fourier transforms, a video filter of infinite bandwidth gives the best results with weak signals. This is also the case when the spectral width of the pulses is greater than that of the i.f. filter, but a video filter of suitable bandwidth gives an improvement when the i.f. filter is wider than necessary for the length of pulse used. Curves are given showing the effect of the video filter on the signal/noise ratios in the different cases.

621.396.823+621.397.823 3152

Telephonic and Radio Interference from High-Voltage Systems.—C. W. Marshall. (*Engineering, Lond.*, 4th Aug. 1950, Vol. 170, No. 4410, p. 103.) Abridged version of report of the International Study Committee to the C.I.G.R.E., 1950. Cases of interference recorded by the B.E.A. during 1949 are tabulated. 53 relate to radio and 28 to television interference.

621.396.828 3153

Research Laboratories of the British Electricity Authority.—J. S. Forrest. (*Nature, Lond.*, 26th Aug. 1950, Vol. 166, No. 4217, pp. 334–335.) Investigations undertaken include research on h.v. transmission using a line 800 yd long operated at 250–300 kV. The intensity of the radio interfering field from the line is being measured and comparisons are being made of the signal/noise ratios for a.m. and f.m. transmissions. Good television reception can be obtained with the aerial only 10 yd from the line conductors.

STATIONS AND COMMUNICATION SYSTEMS

621.39.001.11 3154

Recent Developments in Communication Theory.—C. E. Shannon. (*Tech. Mitt. schweiz. Telegr.-Teleph.-Verw.*, Sept. 1950, Vol. 28, No. 9, pp. 337–342. In German.) Translation of article noted in 1764 of July.

621.39.001.11 3155

Introduction to Signal and Information Theories.—J. Loeb. (*Ann. Télécommun.*, July 1950, Vol. 5, No. 7, pp. 246–254.) A tentative synthesis of published studies in this field. Emphasis is laid on fundamental problems rather than on the theories developed. The discussion covers: (*a*) the analytical signal (1293 of 1948 (Ville)); (*b*) definition of quantity of information for the case of discrete signals; (*c*) the case of continuous signals; (*d*) the relation between information theory and statistical physics.

621.39.001.11 3156

Multiplex and Theory of Communications.—J. Icole. (*Ann. Télécommun.*, Aug./Sept. 1950, Vol. 5, Nos. 8/9, pp. 291–297.) The coefficient of utilization of a radio-telephony channel is defined and its value is calculated approximately for various cases of f.m. and p.m. Its variation with different parameters is determined and shown graphically. The advantage of using several interdependent channels on a single carrier is demonstrated.

621.396.41 3157

Comparison between Multichannel Systems with Common and Multiple Carriers.—P. Güttinger & G. Valko. (*Brown Boveri Rev.*, Dec. 1949, Vol. 36, No. 12, pp. 396–401.) From a theoretical standpoint, the difference between common-carrier and multiple-carrier multichannel systems lies mainly in the causes of crosstalk. With common-carrier systems, both linear distortion in the filters and nonlinearity of the modulation and demodulation processes are responsible, whereas with multicarrier systems, nonlinearity of mixer and output stages is the main cause. Experimental multichannel multicarrier equipment is described, and the most essential technical and test data are given.

621.396.619.11/.13 : 621.397.61 3158

On the Simultaneous Amplitude and Frequency Modulation of a Carrier Wave.—F. Kirschstein. (*Funk u. Ton*, June 1950, Vol. 4, No. 6, pp. 282–292.) Experiments made in 1939 consisted in modulating the amplitude of a low-power 200-kc/s carrier with speech currents and at the same time transmitting a coded signal by keying the carrier to produce a tone of a few hundred c/s. No interference was observed. Using a similar circuit the a.m. carrier was then modulated in frequency by four telegraphy tones of frequencies 120, 360, 600 and 840 c/s. With a.m. above 80%, slight distortion of the f.m. tones occurred. Using two speech channels the f.m. channel was affected by crosstalk. Application of the method for d.s.b. television transmission is discussed, the frequency of the vision-signal carrier being modulated to provide the sound channel.

621.396.619.14 3159

Product Phase Modulation and Demodulation.—D. B. Harris. (*Proc. Inst. Radio Engrs*, Aug. 1950, Vol. 38, No. 8, pp. 890–895.) A modulating voltage e_m impressed in parallel on sine and cosine phase converters produces at their outputs voltages proportional to the functions $\sin ke_m$ and $\cos ke_m$. With two balanced modulators, these modulate respectively the carrier wave, $\cos \omega t$, and the carrier displaced in phase by 90°, $\sin \omega t$, the outputs being added to produce a phase-modulated wave according to the identity $\cos ke_m \cos \omega t + \sin ke_m \sin \omega t = \sin(\omega t - ke_m)$. The phase converters proposed are oscilloscope tubes with the fluorescent screen replaced by an anode for collecting electrons. A mask is interposed in the beam to produce a voltage proportional to the sine or cosine of the linear beam deflection, which in turn is proportional to the modulating voltage applied to the deflection plates. Phase deviations up to $\pm 25\pi$ radians should be obtainable.

621.396.65 3160

Planning Radio Relays.—W. Steinemann. (*Brown Boveri Rev.*, Dec. 1949, Vol. 36, No. 12, pp. 410–414.) Discussion of the various factors which must be taken into account.

621.396.65 3161

Fundamentals for the Planning of Beam Radio Links.—J. Kornfeld. (*Öst. Z. Telegr. Teleph. Funk Fernsehtech.*, July/Aug. 1950, Vol. 4, Nos. 7/8, pp. 85–91.)

621.396.65 3162

A Multichannel Metre-Wave Radio Link with Terminal Stations Outside the Optical Range.—A. Heilmann. (*Fernmeldetech. Z.*, July 1950, Vol. 3, No. 7, pp. 221–233.) Experimental R/T links installed between Berlin and the Western Zone of Germany in and since 1948 are described. Selection of terminal sites in relation to path configuration is discussed; useful results can be expected even when neither terminus is at high elevation. F.m. is used. A link operating on 64 Mc/s in one direction and 68 Mc/s in the other, with a frequency deviation of ± 75 kc/s, gave improved quality and less lost time as compared with earlier links on lower frequencies and with smaller frequency deviations. Receiver input voltages have been recorded continuously for some months, and charts are shown and discussed. An appendix develops formulae for the nonlinear distortion.

621.396.65 3163

Wave Propagation Studies in the Alps.—W. Klein. (*Brown Boveri Rev.*, Dec. 1949, Vol. 36, No. 12, pp. 387–395.) See 2326 of 1949.

621.396.65 : 621.396.5 3164

Multichannel Common-Carrrier Radiocommunication System.—W. Zimmermann. (*Brown Boveri Rev.*, Dec. 1949, Vol. 36, No. 12, pp. 373–378.) A description of the equipment used in the Zürich/Geneva R/T relay. The system uses common-carrier multichannel transmission, a single carrier wave being modulated in frequency by an i.f. signal derived from the frequency-shifted channel signals. Independent 'go' and 'return' channels are used. The frequency range is 150–220 Mc/s and the output of the terminal and repeater transmitters is 50 W. Robust corner reflectors with folded dipoles are used for transmission and for reception. Stand-by equipment is provided.

621.396.65 : 621.396.5 3165

Multiplex Radiotelephone Relays with Pulse-Modulated Microwaves.—H. J. v. Baeyer. (*Brown Boveri Rev.*, Dec. 1949, Vol. 36, No. 12, pp. 379–386.) Description of a 2-way R/T relay operating on frequencies between 1.9 and 2.1 kMc/s and providing 23 telephony channels and one service channel. Pulse-time modulation is used for the speech channels while width modulation is applied to the service-channel pulses. The r.f. pulse power is 30–50 W for a duty cycle of 1 : 5 and the parabolic reflectors commonly used have a gain of about 25 db. With the attenuation figures recommended by the C.C.I.F., the a.f. band extends from 300 to 3 400 c/s.

621.396.65 : 621.396.619.16 3166

Methods of Modulation with Frequency Sharing and with Time Sharing (Pulse Modulation for Multichannel Directional Radio Links.—H. Holzwarth. (*Frequenz*, Feb.–April 1950, Vol. 4, Nos. 2–4, pp. 33–40, 64–71 & 97–101.) The principles of various types of modulation are described and the improvement in signal/noise ratio obtainable by the different systems is investigated. Using double f.m. or p.ph.m., crosstalk between channels may be kept slightly lower than with f.m., which is the best method for single-channel working. Amplitude spectra are given for most of the known modulation systems, p.a.m. and p.w.m. being particularly considered, since these occur in the end stages of most p.m. systems. The distortion is calculated for each method of modulation; with more than six channels distortion is normally extremely small.

621.396.65 : 621.396.822 3167

The Signal/Noise Ratio in a Decimetre-Wave Relay Chain.—P. Barkow. (*Arch. elekt. Übertragung*, April 1950, Vol. 4, No. 4, pp. 155–158.) Measured values are compared with values calculated from three different formulae.

621.396.65 : 621.397.5 3168

A Portable Microwave Television Radio Link.—(*Engineer, Lond.*, 4th Aug. 1950, Vol. 190, No. 4932, p. 128.) Developed by Standard Telephones and Cables for use in a motor van, this f.m. equipment operates on a frequency of about 4 000 Mc/s with a radiated power of 300 mW. The transmitting and receiving circuits are mounted in weather-proof canisters on their associated paraboloid aerials and are respectively connected by coaxial cable to a control and monitor unit, and to a seven-stage i.f. amplifier and a discriminator unit within the van.

621.396.65 : 621.397.5 3169

The London/Castleton Experimental Radio-Relay System.—A. H. Mumford, C. F. Booth & R. W. White. (*P.O. elect. Engrs' J.*, July 1950, Vol. 43, Part 2, pp. 93–99.) A wide-band f.m. system for the transmission of television signals. The mean carrier frequency is 195 Mc/s and four intermediate relay stations are used. To minimize feedback at the relay stations, the receiving and transmitting equipments are located on opposite sides of suitable hills and connected by land line. Rhombic aerials with a forward gain of 15 db with respect to a $\lambda/2$ dipole and with a front/back ratio of 25 db also help to obtain an attenuation between the transmitting and receiving aerials at a repeater station exceeding 120 db. The terminal- and intermediate-station circuits are described and an indication is given of the quality of the transmission of pulse and television signals. See also 2026 of August (Mumford & Booth).

621.396.65.029.63 3170

A Wide-Band V.H.F. Radio-Relay System.—W. S. McGuire. (*A.W.A. tech. Rev.*, June 1950, Vol. 8, No. 4, pp. 295–307.) See 745 of March.

621.396.712 : 534.86 3171

Audio-Frequency Equipment for Broadcasting Services.—J. E. Telfer. (*A.W.A. tech. Rev.*, June 1950, Vol. 8, No. 4, pp. 309–340.) See 2027 of August.

621.396.931 : 621.396.619.13 3172

Mobile Radio Equipment, Type SRR 192.—D. J. Braak. (*Commun. News*, April 1950, Vol. 10, No. 4, pp. 120–125.) Two pre-set frequencies are available in the bands 70–78 Mc/s and 80–86 Mc/s. The frequencies are crystal controlled and f.m. is used.

621.396.932 3173

The Port of Liverpool V.H.F. Radio System.—(*Electronic Engng*, Aug. 1950, Vol. 22, No. 270, pp. 328–330, 337.) See also 2633 of November.

621.396.932.004.15 3174

Radio for Merchant Ships. Performance Specification for Lifeboat Portable Radio Equipment. [Book Notice] —Publishers: H. M. Stationery Office, London, 4d. (*Govt Publ., Lond.*, July 1950, p. 20.)

SUBSIDIARY APPARATUS

621.316.7.078 3175

Contribution to the Study of Automatic Regulation.—M. Cuénod. (*Bull. schweiz. elektrotech. Ver.*, 2nd Sept. 1950, Vol. 41, No. 18, pp. 673–678. In French, with German summary.) The methods of operational calculus are used to study the variations of the regulated quantity following on a disturbance. These variations depend not only on the dynamic characteristics of the regulator, but also on other elements, such as the exciter and generator in the case of voltage regulation. The use of Nyquist curves (response functions) facilitates theoretical investigation of conditions for stability and of variations of the regulated quantity, thus permitting comparison with results obtained in practice.

621.316.722.1 3176

Voltage Stabilizer for 200-kV Acceleration.—J. T. Dewan. (*Rev. sci. Instrum.*, Aug. 1950, Vol. 21, No. 8, pp. 771–772.) A stabilization ratio of 40 is achieved by the use of a 2-stage direct-coupled feedback amplifier, controlling a series regulating pentode. The error signal applied to the amplifier is the difference between a stable balancing voltage and a fraction of the main output, tapped off a 250-M.Ω wire-wound bleeder resistor. Standard regulating devices are used for the supply voltages and pentode heater current to minimize amplifier drift.

621.355 3177

Electrical Accumulators: Recent Patents.—L. Jumau. (*Rev. gén. Élect.*, Aug. 1950, Vol. 59, No. 8, pp. 323–343.) A review of developments in acid and alkaline types of cell. Thermoplastics are being used more and more for cases, separators, frames, etc.

771.36 3178

A 100 000 000-Frame-per-Second Camera.—M. Sultanoff. (*Rev. sci. Instrum.*, July 1950, Vol. 21, No. 7, pp. 653–656.) High photographing rates are obtained with a multislit focal-plane shutter which is transported optically across the film plane by means of a rotating mirror. Application is to self-luminous phenomena such as are associated with explosions.

TELEVISION AND PHOTOTELEGRAPHY

621.396.823+621.397.523 3179

Telephonic and Radio Interference from High-Voltage Systems.—Marshall. (*See* 3152.)

621.397.335 3180

The Effect of Interference on the Synchronization of Television Timebases, and the Remedies to be Applied.—H. Somers. (*Rev. belge Électronique*, May/June 1950, Vol. 2, Nos. 13/14, pp. 3–8.) Synchronization is liable to be destroyed by interference, particularly when negative modulation is used. This disadvantage can be avoided by providing a local control voltage to maintain correct phasing of the scanning. Particular systems discussed are: direct control of the sawtooth oscillations; automatic phase control of a sine-wave oscillator by means of a reactance valve; flywheel circuits. See also 2336 of 1949 (Clark).

621.397.5 3181

TV in England.—J. Moir. (*FM-TV*, Aug. 1950, Vol. 10, No. 8, pp. 12–13, 38.) A report on B.B.C.-controlled development.

621.397.5 : 535.241.44 3182

Brightness and Contrast in Television.—P. C. Goldmark. (*J. Brit. Instn Radio Engrs*, June 1950, Vol. 10, No. 6, pp. 219–225.)

621.397.5 : 621.396.65 3183

A Portable Microwave Television Radio Link.—(*See* 3168.)

621.397.5 : 621.396.65 3184

The London Castleton Experimental Radio-Relay System.—Mumford, Booth & White. (*See* 3169.)

621.397.5(083.74) 3185

Standards for Television Systems.—(*Nature, Lond.*, 16th Sept. 1950, Vol. 166, No. 4220, pp. 472–473.) After examining the state of television in the U.S.A. and in various European countries in March and April 1950, a study group of the C.C.I.R. recommended the following points to the main committee:—(*a*) systems should be independent of power supply frequency; (*b*) picture aspect ratio should be 4 : 3; (*c*) line interlacing should be used in the ratio 2 : 1; (*d*) asymmetric sideband transmission should be adopted for the vision signal; (*e*) standardization of the polarization of the radio transmission is not necessary. Present line standards were retained by France, Great Britain and the U.S.A. See also 2642 of October.

621.397.6 3186

Three-Colour Television System with Faithful Reproduction.—F. Lachner. (*Ost. Z. Telegr. Teleph. Funk Fernsehtech.*, May/June & July/Aug. 1950, Vol. 4, Nos. 5/6 & 7/8, pp. 63–70 & 99–103.) Colour theory is dealt with at some length and the method of representing a colour stimulus by trichromatic coordinates is explained. When applied to colour television the analysis leads to the requirement at the transmitter of colour filters whose frequency response curves have a negative portion between two positive ones. In practice this condition can be simulated by substituting for the negative-response filter one with a positive response of equal absolute magnitude and reversing the current from the associated pickup tube. To make the proper signal additions possible, three pickup tubes, each with associated partial filter, are required for each primary colour. Cross-controlled systems, i.e., where fractions of the signal corresponding to one colour contribute to the control of the other two colours at the receiver, are also discussed.

621.397.6 : 535.88 3187

Recent Progress in Large-Screen Projection of Television Pictures.—A. Cazalas. (*Ann. Télécommun.*, Aug./Sept. 1950, Vol. 5, Nos. 8/9, pp. 298–306.) Developments in cinema television are surveyed, both intermediate-film and projection methods being considered. A projection tube is described in which the fluorescent screen is excited continuously by an auxiliary cathode a little distance from and of about the same area as the screen. Passage of the scanning beam across this cathode produces point-to-point variations of its emission and hence of screen brightness.

621.397.61 : 621.396.619.11/.13 3188

On the Simultaneous Amplitude and Frequency Modulation of a Carrier Wave.—Kirschstein. (*See* 3158.)

621.397.61 : 621.396.619.24 : 621.317.1 3189

Television Transmitter Lower-Sideband Measurements.—Hamilton & Artman. (*See* 3086.)

621.397.62 3190

The TV5 De Luxe.—A. V. J. Martin. (*Télévision*, July/Aug. 1950, No. 5, pp. 133–140.) Detailed design for a reliable, high-quality television receiver, presented as suitable for manufacturers who do not run a television research department of their own.

621.397.645 3191

Television Intermediate-Frequency Amplifiers.—A. Coenraets. (*Rev. belge Électronique*, May/June 1950, Vol. 2, Nos. 13/14, pp. 9–14.) General considerations of bandwidth, gain and frequency response are discussed, typical circuits are described and practical hints on screening are given.

621.397.8 3192

Flicker and Colour Fringing Phenomena in Colour Television.—P. C. Goldmark. (*J. Brit. Instn Radio Engrs*, June 1950, Vol. 10, No. 6, pp. 208–217.) The determination of the threshold of flicker and the maximum permissible highlight illumination in the sequential colour system are discussed. Flicker would be inappreciable at a colour-frame frequency of 60/sec, but a frequency of 48/sec has been adopted due to bandwidth

considerations, giving a threshold of flicker at 23 foot-lamberts for an observation distance seven times the picture height. In a European 50/sec system this value would increase to 40 foot-lamberts. Tests with the field-sequential system have proved that colour fringing is of rare occurrence.

621.397.8 3193

95-Mile TV Reception.—R. F. Allison. (*FM-TV*, Aug. 1950, Vol. 10, No. 8, pp. 14–15.) A report on results obtained under extremely adverse conditions.

621.397.62 3194

The Principles of Television Reception. [Book Review] —A. W. Keen. Publishers: Pitman & Sons, London, 1950, 319 pp., 30s. (*J. Brit. Instn Radio Engrs*, Aug./Sept. 1950, Vol. 10, Nos. 8/9, p. vii.) The book is addressed to the technician rather than the engineer and is nonmathematical. Numerous references facilitate further study, and both British and American practice are described.

TRANSMISSION

621.396.619.029.64 : 621.396.611.4 3195

Microwave Modulation by Variable Circuit Elements comprising Waveguides or Cavity Resonators.—A. N. Bhattacharyya. (*Indian J. Phys.*, April 1949, Vol. 23, No. 4, pp. 175–183.) A driving mechanism similar to that of an electrodynamic loudspeaker is used to vary the dimensions of a waveguide or cavity resonator according to the speech signals, so that microwaves passing through the waveguide may be modulated in either amplitude or phase or the output of the cavity resonator modulated in amplitude.

VALVES AND THERMIONICS

537.533 : 538.3.029.6 3196

Quantum Effects in the Interaction of Electrons with High-Frequency Fields.—J. C. Ward. (*Phys. Rev.*, 1st Oct. 1950, Vol. 80, No. 1, p. 119.) Treating the electron as quantized and the field as classical, the phase-integral approximation is used to predict the probability of energy transfer between the microwave field inside a resonator and electrons projected through the field. When the number of quanta transferred is large, the result tends to that obtained by classical theory.

539.233 : 535.215 3197

Photoadsorption of a Thin Layer of Barium.—Biguenet. (*See* 3030.)

621.315.59 : 621.385 3198

A Crystal Amplifier with High Input Impedance.—O. M. Stuetzer. (*Proc. Inst. Radio Engrs*, Aug. 1950, Vol. 38, No. 8, pp. 868–871.) An amplifier is described consisting of a point- or line-type metal/semiconductor contact, in the neighbourhood of which a high electric field can be applied between an additional electrode and the crystal surface. This can be used to control the current flowing through the rectifying contact. The device has been termed a 'fieldistor'. A.c. response, amplification, noise and d.c. measurements show that the device has a high input impedance and appears useful as an impedance transformer with an appreciable current and power gain at lower frequencies.

621.383.42 3199

Constitution and Mechanism of the Selenium Rectifier Photocell.—J. S. Preston. (*Proc. roy. Soc. A.*, 22nd Aug. 1950, Vol. 202, No. 1071, pp. 449–466.) Experiments are described which indicate the structure and mode of operation of the thin surface film in the Se photocell. Preliminary results on films of Au, Al and Cd, prepared by evaporation in a high vacuum, established the importance of CdO as a film material. A technique is described for sputtering thin films of this compound having high light-sensitivity and conductivity, and open-circuit voltages up to 0.5 V under high illumination. Double films of ZnO and Au were also investigated; these gave a lower sensitivity. It is suggested that in the practical photocell, the essential feature is a contact between two suitable semiconductors of opposite types.

621.385.001.4 (083.74) 3200

Standards on Electron Tubes: Methods of Testing, 1950.—(*See* 3103.)

621.385.029.62/.63 3201

A Survey of Modern Radio Valves: Part 5—Valves for Use in the Range 30–3 000 Mc/s.—R. W. White. (*P.O. elect. Engrs' J.*, July 1950, Vol. 43, Part 2, pp. 78–84.) The poor performance of normal valves at the higher frequencies is discussed and the more important contributory factors are indicated. Desirable design features are tabulated and examples of valves specially designed for use in the above range are briefly described. Part 4: 2058 of August.

621.385.029.63/.64 + 621.396.615.14 3202

Transmitting Valves for Decimetre and Centimetre Waves.—F. M. Penning. (*Commun. News*, April 1950, Vol. 10, No. 4, pp. 109–118.) A review of developments resulting from the application of transit-time effects, the use of cavity resonators, the transfer of energy to the h.f. field by induction, and the use of pulse methods.

621.385.029.63/.64 3203

Traveling-Wave Tubes: Part 3.—J. R. Pierce. (*Bell Syst. tech. J.*, July 1950, Vol. 29, No. 3, pp. 390–460.) Chapter VII develops equations which sum up, in terms of the more important parameters, the linear operation of travelling-wave valves for small values of the gain parameter. The effect of the various parameters on the rate of increase and velocity of propagation of the three forward waves is dealt with in the next chapter. Chapter IX discusses the effect of introducing losses into the circuit and of severing the helix. In chapter X the factors affecting the noise figure are discussed and the conditions for low noise are given. The possibility of the amplification of a nearly synchronous backward-travelling wave is investigated briefly in chapter XI. Appendices deal with the evaluation of the space-charge parameter Q, diode equations, the evaluation of impedance and Q for thin and solid beams, and the calculation of gain. Part 1: 1810 of July. Part 2: 2377 of October.

621.385.029.63/.64 3204

The Travelling-Wave Valve.—L. Brück. (*Arch. Elektrotech.*, 1950, Vol. 39, No. 10, pp. 633–647.) Principle, construction, and properties are described. Details are given for correct design of the electron gun. Alternative delay-line systems are discussed and the influence of voltage, current and helix dimensions on amplification and available h.f. output power are demonstrated by reference to measured characteristics and simplified equations. The possibility of self-excitation and its suppression are considered.

621.385.029.63/.64 3205

The Efficiency of the Travelling-Wave Valve.—O. Döhler & W. Kleen. (*Arch. elekt. Übertragung*, June 1950, Vol. 4, No. 6, pp. 207–212.) Continuation of previous work (2669 of 1949). Expressions are derived for electronic efficiency, circuit efficiency and total efficiency. Circuit efficiency can be calculated exactly, but the formula for electronic efficiency is based on approximations. These are justified by the similarity of results obtained by different methods of investigation.

621.385.029.63/.64 **3206**

On the Operation of the Travelling-Wave Tube at Low Level.—R. Kompfner. (*J. Brit. Instn Radio Engrs*, Aug./Sept. 1950, Vol. 10, Nos. 8/9, pp. 283–289.) The small-signal theory of the travelling-wave valve is developed on the assumption of finite distributed attenuation in the helix and beam voltages other than the 'synchronous' voltage. On restricting the gain parameter z to values <1, a simplified analysis gives results not more than about 6% in error. The voltage gain is then derived for the first 'zero-gain' point, when the valve produces infinite attenuation of an input signal. Under these conditions a measurement of beam current enables an estimate to be made of the effective impedance of the helix, a parameter of considerable importance in design. Theoretical and experimental results are presented.

621.385.032.213 **3207**

Boride Cathodes.—J. M. Lafferty. (*Phys. Rev.*, 15th Sept. 1950, Vol. 79, No. 6, p. 1012.) The thermionic emission properties of the borides of the alkaline-earth and rare-earth metals and thorium have been investigated. These compounds all have the same formula MB_6 and the same crystal structure consisting of a 3-dimensional boron framework in whose interlattice spaces the metal atoms are embedded. The valence electrons of the metal atoms are not accepted by the B_6 complex, thus releasing free electrons which impart a metallic character to these compounds. LaB_6, for example, has a specific resistance of 27 $\mu\Omega$.cm. at room temperature and a positive resistance temperature coefficient of 0.071 $\mu\Omega$/°C. The compounds are very refractory, with melting points above 2 100°C and they are very stable chemically; moisture, oxygen and even HCl do not react with them. At a sufficiently high temperature, surface evaporation of the metal atoms occurs, but is compensated by diffusion from underlying cells so that an active surface is constantly maintained. This feature, together with the high electrical conductivity and high thermal and chemical stability, makes such materials ideal for cathodes. The rare-earth borides have better emission properties than the others, LaB_6 giving the highest emission, nearly twice that of BaB_6 and over 10 times that of CaB_6. Boride cathodes require no special activation; when heated for a few minutes at 1 400–1 600°C for outgassing, they are found to be completely active. Pulsed emission is the same as the d.c. emission. Owing to diffusion of the boron atoms into the lattices of refractory metals normally used as cathode bases, and consequent collapse of the boron framework, tantalum carbide or carbon should be used as the support for boride cathodes.

621.385.032.216 **3208**

The Conduction Mechanism in Oxide-Coated Cathodes.—R. Loosjes & H. J. Vink. (*Philips Res. Rep.*, Dec. 1949, Vol. 4, No. 6, pp. 449–475.) A full account of the work noted in 491 of February. If σ is the conductivity of the oxide coating, T the absolute temperature, I the current (mA/mm²) and V the voltage applied across a 100-μ coating, the curves for $\log \sigma$ against $1/T$ and for I against V can be divided into three parts: (*a*) below 800°K, (*b*) 800–1 000 K, (*c*) above 1 000 K. The $\log \sigma$ curves have low slope in ranges (*a*) and (*c*) and are steeper in range (*b*), while the I/V curves are linear in ranges (*a*) and (*c*) and curved in range (*b*). These results are explained by postulating two conduction mechanisms operating in parallel, one being the electronic conduction through the particles of the oxide coating, the other the conduction through the electron gas in the pores of the coating. A calculation based on the known emission of a well-activated cathode gave a value for the conductivity of the same order of magnitude as that determined experimentally. See also 2934 above.

621.385.2/.3 **3209**

Vacuum Tubes with Mutually Bombarding Oxide Cathodes.—E. G. Hopkins. (*J. appl. Phys.*, Aug. 1950, Vol. 21, No. 8, pp. 841–842.) A diode with closely spaced oxide electrodes can be made to pass a.c. after the removal of the initial heating source, while the same structure with an interposed grid can similarly be used as a triode oscillator. The power usually wasted in anode dissipation can thus be used to heat a cathode surface, and practical power valves are envisaged working on this basis.

621.385.2/.4 : 621.315.59 **3210**

Transistor and Transistron.—M. Adam. (*Tech. mod., Paris*, 1st/15th July 1950, Vol. 42, Nos. 13/14, pp. 220–224.) Design and application developments of the American and French versions of Ge-crystal valves are briefly reviewed. The importance of avoiding confusion with the transitron tetrode oscillator is emphasized. See also 2978 of 1949.

621.385.3.029.64 **3211**

416A Tube for Microwave Relays.—K. P. Dowell. (*FM-TV*, Aug. 1950, Vol. 10, No. 8, pp. 20–22.) A planar triode with high gain-bandwidth product at 4 000 Mc/s is described. New manufacturing and assembly techniques are necessary on account of the close interelectrode spacings.

621.385.38 **3212**

Ignition and Discharge Processes in Gas Triodes.—E. Knoop & W. Kroebel. (*Z. angew. Phys.*, July 1950, Vol. 2, No. 7, pp. 281–285.) Discharge processes in various gases were investigated by means of an oscillograph. The discharge was recorded photographically with time scales of 1.7×10^{-6} to 3×10^{-8} sec per mm of oscillograph trace. From these records the exponential indices of the discharge rise and fall curves were found. With grid ignition the cathode/anode discharge is delayed by a fixed interval after the grid/anode discharge. For Type-EC50 valves (helium-filled) the delay time is 10^{-5} sec; for Type-4690 valves (argon-filled) about 5×10^{-5} sec. The difference is attributed to the effect on transit time of the greater mass of the argon ions. No fluctuations were observed in the time of occurrence of ignition or discharge.

621.385.832 : 621.318.572 **3213**

Valves with a Ribbon-Shaped Electron Beam: Contact Valve; Switch Valve: Selector Valve; Counting Valve.—J. L. H. Jonker. (*Philips Res. Rep.*, Feb. 1950, Vol. 5, No. 1, pp. 6–22.) A discussion of results obtained in the development of special c.r. tubes. The size of such tubes can be reduced so much that customary valve techniques can be applied in their construction. The new possibilities thus created are illustrated by (*a*) an electronic contact valve, which may serve as a telephony switch, (*b*) a valve of similar design to replace magnetic relays, (*c*) a multicontact switch valve, and (*d*) a high-speed counting valve. See also 1801 of July.

621.396.615.141.2 **3214**

A Simple Approximate Formula for the Resonance Frequency of a Cavity Magnetron.—F. Borgnis. (*Z. angew. Phys.*, July 1950, Vol. 2, No. 7, pp. 278–280.) The magnetron multicavity system is usually considered as a number of similar coupled oscillatory systems. It is here treated as a cylindrical waveguide with plane metal ends, the actual boundary of the cavity coinciding approximately with the hypothetical surface containing the magnetic field lines of the corresponding circular-section waveguide. A very simple formula is thus obtained for the desired (π-mode) resonance frequency. A numerical example is worked for $\lambda = 1$ cm.

621.396.615.142 3215

Theory of Velocity-Modulation Transit-Time Valves: Parts 3 & 4.—H. Döring. (*Arch. elekt. Übertragung*, April & June 1950, Vol. 4, Nos. 4 & 6, pp. 147–153 & 223–231.) The commencement of oscillations is considered for the theoretical case of a valve with infinitely short alternating fields (electrical double layer). The lower part of the general efficiency curve is represented by a parabolic approximation, which is applied to determine the conditions necessary for oscillations to begin. The practical case of valves with alternating fields of finite length is then treated and conditions for oscillation are determined for single-field valves, drift valves with in-phase or out-of-phase alternating fields, and reflex valves. Part 1: 2175 of 1944. Part 2: 2034 of April.

621.385+621.396.611.1].029.6 3216

Technique des ondes très courtes et ultra-courtes: Tome I—Circuits oscillants et tubes à vide. [Book Review]—Liot. (*See* 3017.)

MISCELLANEOUS

53 3217

Physics Research at T.R.E.—R. A. Smith. (*Science*, 21st July 1950, Vol. 112, No. 2899, pp. 71–73.) Work on electronics, millimetre waves, semiconductors, infra-red radiation, radio meteorology, low temperature and theoretical physics is briefly described.

621.396.69 : 061.4 3218

Radio at the 39th Paris Fair.—R. Ar. (*Radio franç., Paris*, June 1950, Vol. 19, No. 185, pp. 15–28.) General survey of exhibits, with notes on individual receivers (radio and television), aerials, loudspeakers, gramophones, intercommunication equipment and electronic apparatus.

621.3.089.6+53.001.4 3219

Testing by the National Bureau of Standards. N.B.S. Circular 483. [Book Review]—National Bureau of Standards. Publishers: U.S. Government Printing Office, Washington, 1949. 25 cents. (*Engineering, Lond.*, 4th Aug. 1950, Vol. 170, No. 4410, p. 102.) This document states the Bureau's policy regarding testing, outlines the procedure for applying to have tests carried out, and sets out in detail the types of test which can be made and the schedule of fees.

621.39.029.64 3220

Les Hyperfréquences, Circuits et Propagation des Ondes (en vue de l'Application au Radar et aux Télécommunications). [Book Review]—R. Rigal. Publishers: Éd. Eyrolles, Paris, 1950, 219 pp., 1470 fr. (*Ann. Télécommun.*, July 1950, Vol. 5, No. 7, p. 276.) The author is Directeur des Études à l'École Nationale Supérieure des Télécommunications, and the book covers his course for engineering students.

621.396 3221

N.A.B. Engineering Handbook, Fourth Edition. [Book Review]—Publishers: National Association of Broadcasters, Washington, D.C., 1949. 650 pp., $17.50. (*Proc. Inst. Radio Engrs*, Aug. 1950, Vol. 38, No. 8, p. 902.) "The material in part consists of reprints of articles appearing in various technical magazines, and in part of articles directly written for this handbook. The style and content is therefore variable . . . It is recommended to the attention of all engineers who are engaged in broadcast and television activities."

ABSTRACTS AND REFERENCES INDEX

The Index to the Abstracts and References published throughout the year is in course of preparation and will, it is hoped, be available in March, price 2s. 6d. (including postage). As supplies are limited our Publishers ask us to stress the need for early application for copies. Included with the Index is a selected list of journals scanned for abstracting, with publishers' addresses.

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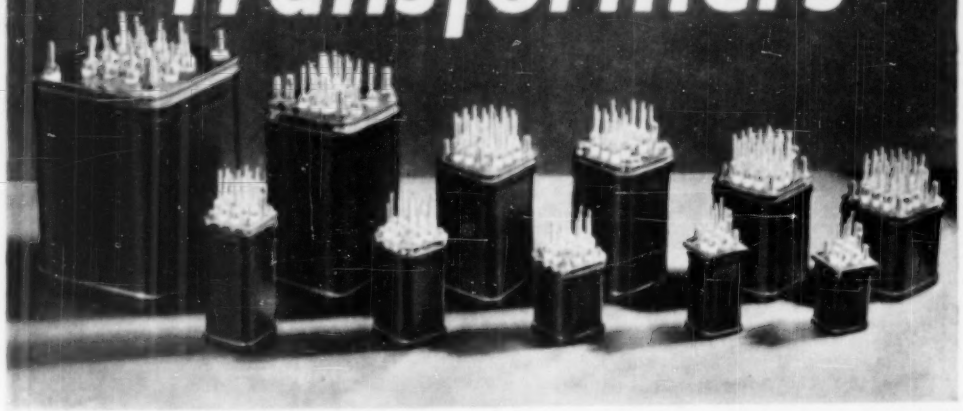

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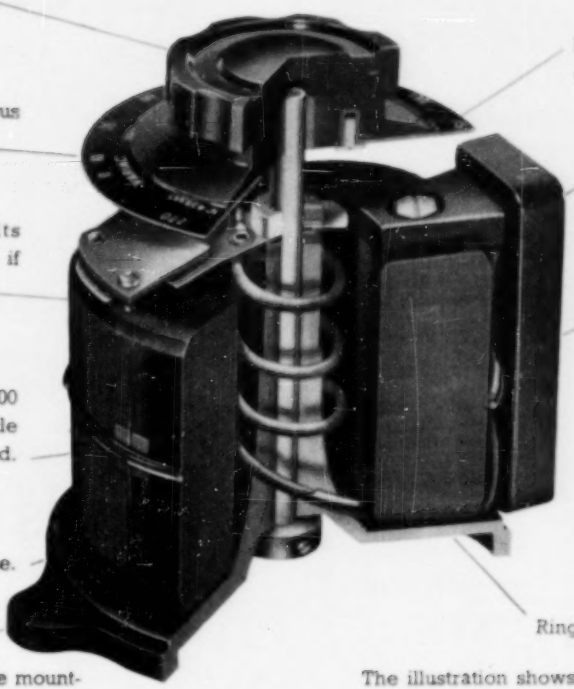

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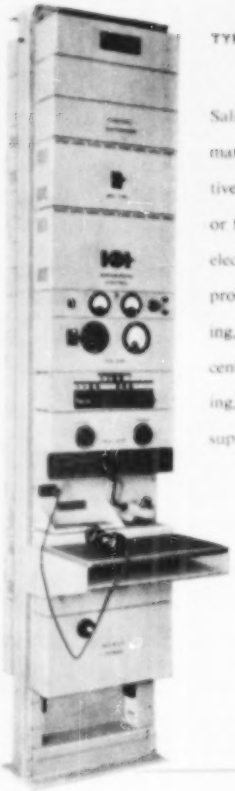

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C22	5.5	184	2.8	0.44
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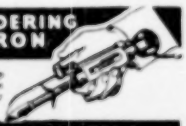

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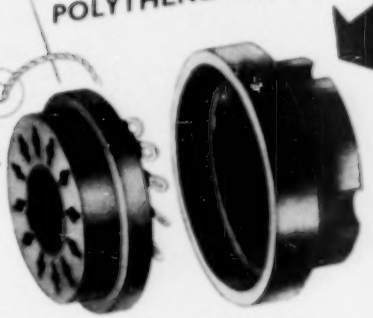

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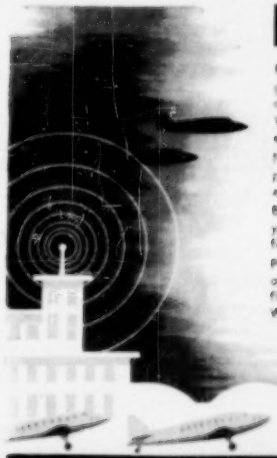

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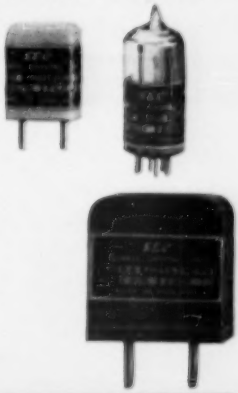

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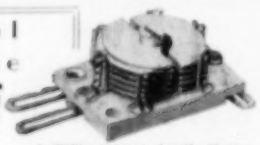

★ Width: 1·6 m/m. Length: 10 m/m. Height:
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The quality and reliability of Ersin Multicore Solder have made it the choice of manufacturers in every corner of the globe — even in America, where many home-produced brands can be obtained at a lower price. Manufacturers and service engineers know that their reputation depends on the quality of the solder they use—that is why they use only the Finest Cored Solder in the World.

VIRGIN METALS

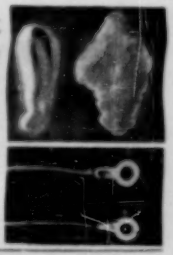
Ersin Multicore Solder is made from purest tin and lead, alloyed in unvarying proportions. All alloys are assayed by an independent test firm, and an A.I.D. certificate is issued for each batch. Users of Ersin Multicore Solder are thus assured that every consignment they order has the same guaranteed characteristics.

THE SECRET OF ERSIN FLUX

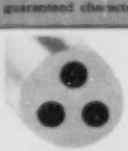
Ersin, the flux contained in three cores of Ersin Multicore Solder, is a high grade rosin which has been subjected to a complex chemical process to increase its fluxing action, without impairing the well known non-corrosive properties of the original rosin. Ersin not only prevents oxidation during soldering, but actually cleans any oxides from the surface of the metal.

SUPERIOR FLUXING PROVED BY TESTS

In the test shown in the upper photograph, equal weights of Ersin Multicore and an ordinary single core solder were heated on a plate. The single core solder (left) has hardly spread at all, while the Ersin Multicore Solder (right) has spread considerably, demonstrating its much greater fluxing action. In the lower photograph, Tag A was soldered with single core rosin solder, which has adhered only to the copper wire. This is a typical 'dry' joint. Tag B was soldered with Ersin Multicore Solder, which has spread evenly over wire and tag, making a sound joint.



WHY 3 CORES?



The three-core construction—exclusive to Ersin Multicore—means thinner solder walls, quicker melting and speedier soldering. Flux continuity is assured—there are no wasted solder lengths without flux. Used with the correct soldering technique, Ersin Multicore Solder gives complete freedom from 'dry' or H.R. joints.

500 REASONS IN EVERY RADIO SET

The average domestic radio receiver contains about 500 soldered joints. If even one of these joints is made with solder containing either no flux at all or a flux which does not remove all the surface oxide, a 'dry' or H.R. joint may be produced. Only Ersin Multicore gives a consistently high standard of sound precision soldered joints.

ALLOYS AND MELTING POINTS

ALLOY Tin/Lead	B.S. Grade	MULTICORE Colour Code	MELTING TEMPERATURES Solidus of all these alloys is 183° C.—361° F. °C. Liquidus	°F.	Recommended bit temperature °C.	°F.	USES
60·40	K	Red	189	372	229	444	High quality work requiring low melting point alloy.
50·50	F	Yellow	214	417	254	489	Hand soldering, radio, telephone and electrical equipment; batteries.
45·55	(M)	Crimson Buff	225	437	265	509	
40·60	G	Green	232	450	272	522	
30·70	J	White	255	491	295	563	Fuses, motors, dynamos.
20·80	—	Purple	275	527	315	599	Lamps, motors, dynamos.

STANDARD GAUGES

Standard Wire Gauge	Diam. in inches	Diam. in M.ms.	Approximate Number of Feet per lb. ALLOY Tin content is shown first 60·40	50·50	45·55	40·60	30·70	20·80
10	·128	3·251	24·5	23·6	23·3	22·7	21·6	20·8
12	·104	2·642	37·2	35·7	35·2	34·6	32·7	31·5
13	·092	2·337	47·5	45·6	45	44	41·9	40·4
14	·080	2·032	62·8	60·2	59·4	58	55·2	53·2
16	·064	1·626	98	94·3	93	91	86·5	83·4
18	·048	1·219	174·5	167	165	161	154	148
19	·040	1·016	251	241	238	232	221	212
20	·036	·914	310	298	294	287	273	263
22	·028	·711	512	492	486	474	452	436

ACCURATE ALLOYS

The limits of metal contents are in conformity with B.S.S. 219, 1949. By using only virgin metals the incidence of impurities has been reduced below the maximum allowed by B.S.S. 219: 1949. All alloys comply with U.S. Federal Specifications.

This table shows lengths for 1 lb. Ersin Multicore Solder having 3·2% approximate flux content. Solder supplied with 3·5% approximate flux content has a slightly greater length per lb. Maximum economy is secured by choosing the solder with the lowest flux content, compatible with obtaining sufficient fluxing ability.

Write for a copy of "Modern Solders" which gives full technical information about ERSIN MULTICORE SOLDER.

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